



*Library of the School of Medicine
University of Leeds*



*From the library of
The Right Honourable Lord Moynihan
of Leeds*

1865 — 1936

Professor of Surgery

STACK
WE 200
ROL

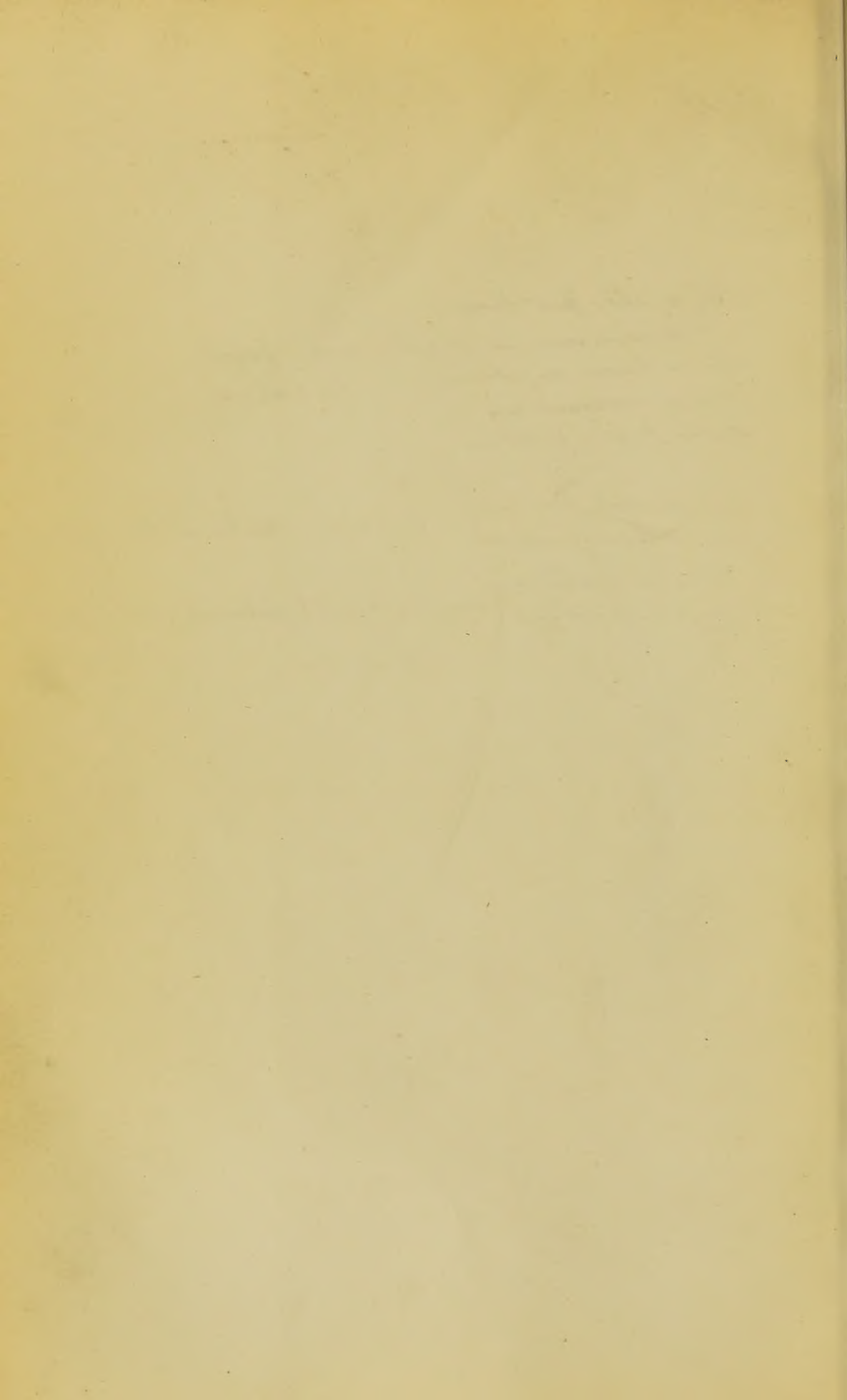


30106

004185210

Nasty Man Lacks Pale turn
vomit

Nov. 1874



Herbert J. Robson.

HUMAN OSTEOLOGY

BY THE SAME AUTHOR.

MANUAL OF DISSECTION OF THE
HUMAN BODY.

WITH NUMEROUS ILLUSTRATIONS.

NEW EDITION IN THE PRESS.

LANDMARKS,
MEDICAL AND SURGICAL.

SECOND EDITION, 8vo. 3s. 6d.

HUMAN OSTEOLOGY

COMPRISING

A DESCRIPTION OF THE BONES

WITH DELINEATIONS OF THE ATTACHMENTS OF THE MUSCLES
THE GENERAL AND MICROSCOPIC STRUCTURE OF BONE
AND ITS DEVELOPMENT

BY

LUTHER HOLDEN, F.R.C.S.

VICE-PRESIDENT AND MEMBER OF THE COURT OF EXAMINERS OF THE ROYAL COLLEGE
OF SURGEONS OF ENGLAND; SURGEON TO ST BARTHOLOMEW'S
AND THE FOUNDLING HOSPITALS

FIFTH EDITION, REVISED BY THE AUTHOR

WITH THE ASSISTANCE OF

Henry Griffiths.

ALBAN DORAN, F.R.C.S.

LATE ANATOMICAL, NOW PATHOLOGICAL, ASSISTANT TO THE MUSEUM OF THE ROYAL COLLEGE OF
SURGEONS OF ENGLAND; SURGEON TO OUT-PATIENTS, SAMARITAN FREE HOSPITAL



With numerous Illustrations

LONDON

J. & A. CHURCHILL, NEW BURLINGTON STREET

1878

TO THE
STUDENTS OF ST BARTHOLOMEW'S HOSPITAL

IN TESTIMONY OF HIS EARNEST REGARD, AND
IN REMEMBRANCE OF THE KIND AND CONSIDERATE FEELING
WHICH THEY HAVE EVER EVINCED TOWARDS HIM

This Work is Dedicated

BY THEIR SINCERE WELL-WISHER AND FRIEND

THE AUTHOR

PREFACE

TO

THE FIFTH EDITION.

IN PREPARING the present Edition the author has been assisted by Mr ALBAN DORAN, lately Anatomical Assistant to the Museum of the Royal College of Surgeons of England.

In revising the Attachments of Muscles, note has been taken of the highly instructive dissections (made by Mr. W. PEARSON in the work-rooms of the College) which are now in the Physiological Series of the Museum.

Most of the Plates have been re-drawn. Numerous woodcuts have been added, in illustration of the Development of Bone—for which, as well as for other collateral work, the author is indebted to Mr JAMES SHUTER, Assistant Demonstrator of Anatomy at St Bartholomew's Hospital.

Grateful acknowledgments are due to Professor FLOWER, F.R.S., and to the Demonstrators of St Bartholomew's Hospital, for valuable suggestions in special details.

September 1878.

PREFACE

TO

THE FIRST EDITION.

THIS WORK is intended as an introduction to the *Manual of Anatomy* already published by the author. Its object is to teach the student the Bones, and the accurate Attachments of the Muscles. Practical observations are here and there interspersed. The plan of the plates is novel, and speaks for itself; it is only necessary to explain that the red outlines denote the origins of muscles; the blue, the insertions.

The Microscopic Structure of Bone has been introduced, because such knowledge is essential to a right understanding of its diseases. This part of the work has passed under the eye of Professor QUEKETT. The author is deeply indebted to that gentleman for his kindness in imparting information, and permitting access to his beautiful drawings and preparations, of which liberal use has been made.

To Professor OWEN the gratitude of the author is especially due for his kindness in looking over the concluding part of the

work, relating to the Unity of Type in the construction of the Vertebrate Skeleton.

The drawings have been executed on stone by Mr GODART with his usual accuracy and spirit, deserving the author's best acknowledgments.

September 1855.

PREFACE

TO

THE SECOND EDITION.



IN the Second Edition of this work the author has added the Cartilages and Muscles of the Larynx, and the Anatomy of the Internal Ear. These subjects are respectively illustrated by additional plates and numerous wood engravings.

September 1857.

CONTENTS.

	PAGE	PLATE
GENERAL OBSERVATIONS ON THE STRUCTURE OF BONE	1	. . I. to v.
MICROSCOPIC STRUCTURE OF BONE	13	
STRUCTURE OF CARTILAGE	22	
DEVELOPMENT OF BONE	23	
THE VERTEBRAL COLUMN	37	. . v., vi., vii.
BONES OF THE SKULL	55	
Occipital Bone	55	. . viii.
Parietal Bone	60	. . ix.
Frontal Bone	62	. . x.
Temporal Bone	68	. . xi., xii.
Sphenoid Bone	77	. . xiii., xiv.
Ethmoid Bone	86	. . xiv.
BONES OF THE FACE.		
Superior Maxillary Bone	90	. . xv.
Malar Bone	98	. . xvi.
Nasal Bone	99	. . xviii.
Lachrymal Bone	101	. . xvii.
Palate Bone	102	. . xvi., xvii.
Inferior Spongy or Turbinated Bone .	105	. . xix.
Vomer	107	. . xviii.
Inferior Maxillary Bone	108	. . xxii.
THE SKULL AS A WHOLE	113	
Sutures	113	} . . xxvii.
Skull-cap	115	
Base of the Skull as seen from within	119	. . xxiii.
Base of the Skull as seen from below	122	. . xxiv., xxv.
Temporal, Zygomatic, Spheno-max- illary Fossæ	127	. . xix., xxvi.
The Orbits	128	. . xxvi.
Nasal Fossæ	131	. . xx., xxi.
General Observations on the Skull .	133	

	PAGE	PLATE
BONES OF THE UPPER EXTREMITY	138	
Clavicle	138	} . . XXVIII., XXIX.
Scapula	141	
Humerus	145	. . XXX., XXXI.
Radius	151	} . . XXXII., XXXIII.
Ulna	155	
BONES OF THE HAND	159	
Carpus	159	} . . XXXIV. to XXXVI.
Metacarpus	165	
BONES OF THE FINGERS	168	
Sesamoid Bones	170	
Interosseous Muscles	170	
BONES OF THE LOWER EXTREMITY	172	
Os innominatum	172	} . . XXXVII. to XXXIX.
Ilium	173	
Pubes	176	
Ischium	177	
Sacrum	182	} . . XXXVIII., XXXIX.
Coccyx	186	
Pelvis in general	187	. . XLI.
Femur	191	. . XLII., XLIII.
Patella	199	} . . XLIV.
Tibia	200	
Fibula	204	
BONES OF THE FOOT	208	
The Astragalus	210	} . . XLV., XLVI.
Os Calcis or Calcaneum	212	
Os Scaphoides	215	
Os Cuboides	216	
Ossa Cuneiformia	217	
Metatarsus	220	
Sesamoid Bones	223	
Phalanges	223	
OBSERVATIONS ON THE FOOT AS A WHOLE	225	
INTEROSSEOUS MUSCLES OF THE FOOT	227	
THE THORAX	228	
Sternum	229	} . . XLVII. to L.
Ribs	231	

CONTENTS.

XV

	PAGE	PLATE
MUSCLES OF THE BACK	238	. . L. to LV.
Muscles of the Back of the Neck	240	
Muscles in front of the Spine	241	
OS HYOIDES	242	. . LVI.
GENERAL SURVEY OF THE SKELETON	244	
THE LARYNX	248	. . LVII.
THE ANATOMY OF THE EAR	259	. . LVIII. to LXI.
INDEX	281	



..... Cranium.

7 Cervical vertebræ.

..... Clavicle.

..... Scapula.

12 Dorsal vertebræ.

..... Humerus.

5 Lumbar vertebræ.

..... Ilium.

..... Ulna.

..... Radius.

..... Bones of the Carpus.

..... Bones of the Metacarpus

..... Phalanges of the fingers.

..... Femur

..... Patella.

..... Tibia.

..... Fibula.

..... Bones of the Tarsus.

..... Bones of the Metatarsus

..... Phalanges of the toes.

HUMAN OSTEOLOGY.

IMPORTANCE AND INTEREST OF OSTEOLOGY.

WHOEVER would become a good anatomist and a skilful surgeon must make himself master of Human Osteology. It must be, not only his first, but his principal and constant study. During his dissections he ought to be continually referring to the skeleton. He cannot reduce the simplest dislocation without a competent knowledge of the bones. The subject appears dry and tedious to a beginner—what study indeed does not?—but a little progress will convince him that, so far from being dry, it is full of interest, not only as conducive to professional success, but for its own sake. No part of creation displays more manifest design than the human skeleton. Undertaken in a right spirit, the study of it becomes, with many, a favourite pursuit,—leads us to look a little beyond ‘final purposes,’ and creates a natural longing to know something of the skeleton of the lower animals, that we may the better judge of the admirable construction of our own; for it is only by comparison that we can *judge*. When the great truth unfolds itself, that our own structure is but a modification of the ‘one common pattern’ upon which all vertebrate animals are formed, we cannot but feel with the philosophic poet, that—

’Tis the sublime of man,
Our noontide majesty, to know ourselves
Parts and proportions of a wondrous whole.

COLERIDGE.

USES OF THE BONES.

The bones form a framework for the moulding and support of the soft parts of the body: they form cavities for the lodgment and protection of delicate organs.—

e.g. the skull for the protection of the brain; the vertebral canal for the protection of the spinal cord; the orbits for the protection of the eyes; the chambers in the temporal bone for the protection of the internal ear; the chest for the protection of the heart and lungs, &c.: they form the joints for the locomotion of the whole body, as well as for the movement of its individual parts: they form levers for the action of the muscles.

**GENERAL COM-
POSITION OF BONE.
ITS ANALYSIS.** Bone is composed of a basis of animal matter impregnated with 'bone earth' or phosphate of lime. The first ingredient makes it tenacious and elastic; the second gives it the requisite hardness. The analysis is easily made. Place a bone in a solution of one part of dilute hydrochloric acid to five or six of distilled water; in a few days all the earthy part will be dissolved out by the acid, and the animal part will be left. The bone will be scarcely altered in shape or colour, but it can be bent and twisted in any direction. To get rid of the animal matter, we have merely to boil the bone for a long time; or the bone may be calcined till all the animal matter is burnt out. In either of these ways the animal constituent of the bone will be removed, and nothing left but the earthy. The animal matter consists of gelatin (or glutin), which is nearly all soluble in boiling water. Everyone knows that soup may be made out of bones. Notwithstanding their antiquity, fossil bones are found to contain nearly as much animal matter as recent bones. Gimbernat made soup from the gelatin of the mastodon's tooth, as Dr. Buckland afterwards did from the fossil bones of the hyæna.

**RELATIVE PRO-
PORTIONS OF THE
ANIMAL AND
EARTHY MATTER.** As to the relative proportions of the animal and earthy matter in bone, the best chemists agree that the animal part forms about *one third*, the earthy *two thirds*. Are these proportions constant? Do they vary at different periods of life, and in different bones of the skeleton? It is the generally received opinion that they *do* vary. It is believed that the animal element predominates in the bones at the beginning of life, and the earthy element at the decline. This is assigned as the reason why the bones of children are so elastic, so liable to be indented, as by a blow on their skull-cap, and to bend like a green stick rather than break like the

bones of the aged. Some recent investigators,* however, have impugned the correctness of this opinion. Their analyses go to prove that *equal weights* of bone tissue contain, at all ages, and in all bones, nearly the same relative proportions of animal and earthy matter. A particle of bone, they say, is a definite, not a variable compound. The hardness and compactness of bone depend, not upon the variations of its earthy ingredient, but upon the quantity of bone condensed in a given space. The peculiarity of the bones of children arises from the greater sponginess of their texture, and from the layers of cartilage introduced in appropriate parts to facilitate growth and to break shocks.

BERZELIUS'S ANALYSIS OF BONE. The following is Berzelius's analysis of adult human bone:—

Animal matter	33·30
Earthy matter, namely—	
Tribasic phosphate of lime	51·04
Carbonate of lime	11·30
Fluoride of calcium	2·00
Phosphate of magnesia	1·16
Soda and chloride of sodium	1·20
	<hr/>
	100·00

DR. BOSTOCK'S ANALYSIS OF RICKETY BONES. In the disease of early life called 'rickets,' in which the bones bend and become distorted, from deficiency of earthy matter, Dr. Bostock found the proportions of animal and earthy matter to be—

Animal matter	79·75 per cent.
Earthy matter	20·25 „

* Dr. Stark, 'Edinb. Med. and Surg. Journal,' April 1845; Nélaton, 'Eléments de Pathologie,' t. i. p. 636.

Mr. R. Tuson, Demonstrator of Chemistry at St. Bartholomew's Hospital, has given me the subjoined analysis of 100 parts, by weight, of human long bones of different ages:—

	At birth.	10 Years.	36 Years.	71 Years.
Organic matter	35·37 . . .	32·62 . . .	32·04 . . .	32·94 . . .
Inorganic matter	64·63 . . .	67·38 . . .	67·96 . . .	67·06 . . .
	<hr/>	<hr/>	<hr/>	<hr/>
	100·00	100·00	100·00	100·00

Of all animals, the bones of birds (especially of the predaceous kind) contain the largest proportion of earthy matter. Hence their great compactness and white colour. The bones of mammalia come next; then those of reptiles; and last of all those of fishes.

IMPORTANCE OF
PHOSPHATE OF
LIME. Of the earthy ingredients of bone the phosphate of lime holds by far the first rank; hence it is commonly called 'bone earth.' Adult bone contains 51 per cent. of it, and about 11 per cent. of the carbonate of lime. Carbonate of lime is the principal ingredient in the hardening of shells. But the phosphate of lime is used to harden bone, because it forms a harder compound with animal matter than the carbonate. What can be harder than the enamel of the teeth? And this consists of a very large proportion of phosphate of lime combined with animal matter. According to Berzelius, there is only 2 per cent. of animal matter in the enamel, and of the remaining 98 parts, $88\frac{1}{2}$ consist of phosphate of lime.

Phosphate of lime enters not only as the principal earthy ingredient into the composition of bone, but is contained, more or less, in nearly all the tissues of the body. Of all inorganic materials it appears to be the most essential both for vegetable and animal life. Therefore it is not only a most important article of diet, but also a necessary manure. 'Those parts of plants which experience has taught us to be the most nutritious, contain the largest proportion of the phosphates,—such as bread-corn, peas, beans, and lentils.'* It has been ascertained by experiment, that if animals have their entire supply of phosphate of lime cut off, after some weeks of illness, they are attacked with diarrhœa, which soon kills them. Their bones are found very much softened; and it is not unlikely that the phosphates are absorbed from their bones to supply other more important structures, such as the nerves and muscles.

It is the quantity of phosphate of lime in the bones which makes them so valuable as manure. The bones are boiled to extract the gelatin or glue; afterwards they are crushed in a mill, and, as 'bone dust,' form an extensive article of commerce.

* Liebig's 'Letters on Chemistry,' p. 522.

STRENGTH OF
BONE.

From the experiments of Professor Robinson, it appears that the strength of bone, as contrasted with other substances, is remarkable. He found that the following materials stood in point of strength to each other thus:—

Fine freestone, as	1·0
Lead	6·5
Elm and ash	8·5
Box, yew, oak	11·0
Bone	22·0

Hence bone is twice as strong as oak. Professor Robinson found that a piece of bone an inch square would bear 5,000 lbs. weight.* Besides this, we shall presently see that bone is constructed so as to give the greatest strength with the least expenditure of materials. The specific gravity of bone is from 1·87 to 1·97.

ELASTICITY OF
BONE.

In consequence of the animal matter they contain, bones possess a certain amount of elasticity. If a skull be thrown upon the ground, it will rebound. The degree of elasticity varies in different bones, according to their form and texture. The clavicle, for instance, owing to its curved form, is remarkably elastic,—a property which enables it to break the shock of a fall upon the hand. If one end of a clavicle be placed at a right angle against a hard substance, and the other end struck smartly with a hammer, the bone will rebound to a distance of nearly two feet. The ribs, too, are exceedingly elastic. The Arab children make excellent bows with the ribs of camels. Perhaps the best instance of elasticity in bone is the clavicle (merry-thought) of the bird. It acts as a spring, and restores the base of the wings to their proper position after the action of the muscles of flight. All the long bones in the human body are more or less curved, that they may have the benefit of elasticity.

DIVISION OF
BONES INTO THREE
CLASSES.

Though the bones present every variety of form and size, yet, for convenience of description, anatomists divide them into three classes:—1. The long and round; 2. The broad and flat; 3. The short and square,

* Gregory's 'Mechanics,' vol. i. c. v.

or irregular. The long and round form the great levers of the limbs, and are adapted for motion. The broad and flat are found chiefly in the skull and pelvis, and are adapted for protection. The short and irregular are for limited motion combined with strength; as the bones of the spine, the carpal and tarsal bones.

NOMENCLATURE.

In describing the different parts of a bone, we use terms,—Latin, Greek, or English,—which denote either the form of the part, or its fancied resemblance to some natural object, or the purpose it serves. We soon become familiar with such terms as ‘eminences,’ ‘depressions,’ ‘processes,’ ‘tuberosities,’ ‘spines,’ ‘foramina,’ ‘notches,’ ‘canals,’ ‘sinus,’ ‘fossæ,’ ‘trochanters,’ ‘condyles,’ etc. Again, there are parts of bones named after some celebrated anatomist, who first described them: for instance, the ‘aqueduct of Fallopius,’ ‘the antrum of Highmore,’ ‘the fissure of Glaser,’ the ‘canal of Vidian,’ etc.

STRUCTURE OF BONE. COMPACT AND CANCELLOUS TISSUE.

Let us examine, first, the structure of bone, as it can be seen with the naked eye; afterwards, its minute structure with the microscope. Lastly, we will study the development and growth of bone.

The best way to obtain a rough idea of the structure of bone is to make a vertical section through one of the long bones—say the femur—all the way down (Plate I.). We then see that the outer part, or ‘wall,’ of the bone is compact like ivory; the interior is hollow, forming the ‘medullary canal,’ or cavity containing the marrow. The ends, which expand to form the joints, are composed of a beautiful network of plates and columns of bone, forming what is called ‘cancellous or spongy tissue,’ which in the recent state is also filled with marrow.

SHAFT OF A BONE, WHY HOLLOW.

Why is the shaft of a long bone hollow? Not only for lightness’ sake, but because, the amount of material being the same, a hollow cylinder is much stronger than a solid one. It is proved that the lateral strengths of two cylinders of equal weight and length, of which one is hollow and the other solid, are, respectively, as the diameters of their transverse sections; provided always that the diameter of

the tube be within certain dimensions. Thus, let $a b, c d$ (figs. 1 and 2) represent the sections of two cylinders; then the strength of the tube $c d$ is to that of the solid $a b$ as the line $c d$ is to $a b$.*

In the early part of the seventeenth century, Galileo observed that nature, on this principle, increases in a variety of instances the strength of bodies without adding to their weight. This most profound philosopher, when accused of atheistical opinions, and interrogated before the Inquisition as to his belief in a Supreme Being, picked up a straw from the floor of his prison, and replied, 'If there were nothing else in nature to teach me the existence of a Deity, even this straw would be sufficient.'

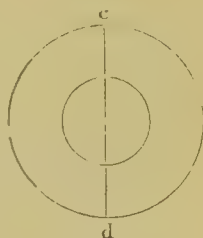
AIR CELLS IN
BONE.

Thus are strength and lightness combined in the economy of bones. This principle is carried to the extreme in the bones of birds, which are filled with air instead of marrow. There is a communication between the lungs and the cavities in the bones of birds; and the air which fills the bones being warm, renders them still lighter. It was formerly believed, that the extent to which air is admitted into the skeleton of birds varies according to their powers of flight. But Huxley† has pointed out that this relation does not hold good in all instances, since in the ostrich the bones are more pneumatic than in the gulls and in the smaller song birds. The great beak of the hornbill forms one great air cell; even the thin columns of the cancellous tissue in the interior are hollow and filled with air. In this bird, in the swifts and the humming-birds, every bone of the skeleton, down to the little bones of the claws, is filled with air. In the little 'apteryx' of New Zealand, which has no available wings, and in the penguin, which never or rarely leaves the water, not any bone of the skeleton except those of the skull receives air. In mammalia there are no air cells except in the bones of the head. There are large air cells (sinuses) in the frontal,

FIG. 1.



FIG. 2.



* Bishop 'On Deformities,' 1852, p. 14.

† 'Manual of Anatomy of the Vertebrated Animals.'

sphenoid, ethmoid, palate, maxillary and mastoid bones in man. But in some animals these air cells are carried to a much greater extent. The most remarkable development of air cells in the mammalia is seen in the skull of the elephant. His intellectual physiognomy is caused, not by the size of the brain case, but by the enormous air cells between the two plates or tables of the skull. The same may be said of the owl. In the giraffe there is the same arrangement of air cells between the two tables of the skull. In the great extinct sloths the upper, back, and side walls of the cranium were thus inflated with air; so that in these instances the brain is, as it were, protected by a double skull, with air between the two. This modification not only lightened the skull, but protected the brain from the falling trees uprooted for food by these animals.

BONE DIVISIBLE
INTO LAYERS.

Although the compact tissue of bone seems hard and solid as stone, yet it is made up of layers placed so close together, that there is no apparent interval between them. Towards the articular ends (Plate I. fig. 3), the layers gradually separate to form the cancellous tissue, and the compact tissue becomes thinner in proportion. In bones that have been long weatherbeaten in a churchyard, these layers may be peeled off one after another; or if the earthy matter be removed by acid, the animal matter admits of being stripped off like so many leaves. It

FIG. 3.



is essential to bear in mind this lamellar structure of bone, because it explains what is observed in cases of inflammation of bone—namely, that the enlargement of the blood-vessels together with the inflammatory deposit separates the layers from each other, and thus causes the bone to expand and be perceptibly increased in diameter, as seen in the adjoining wood-cut (fig. 3), taken from a preparation in the museum of St. Bartholomew's Hospital.

CANCELOUS
TISSUE. ADAP-
TATION OF ITS
LAYERS TO THE
WEIGHT TO BE
SUSTAINED.

The cancellous tissue occupies the interior of bones, and chiefly the articular ends. It is formed by the separation of the component layers of the bone, and these are connected by cross plates and fine columns, so as to form a kind of lattice-work

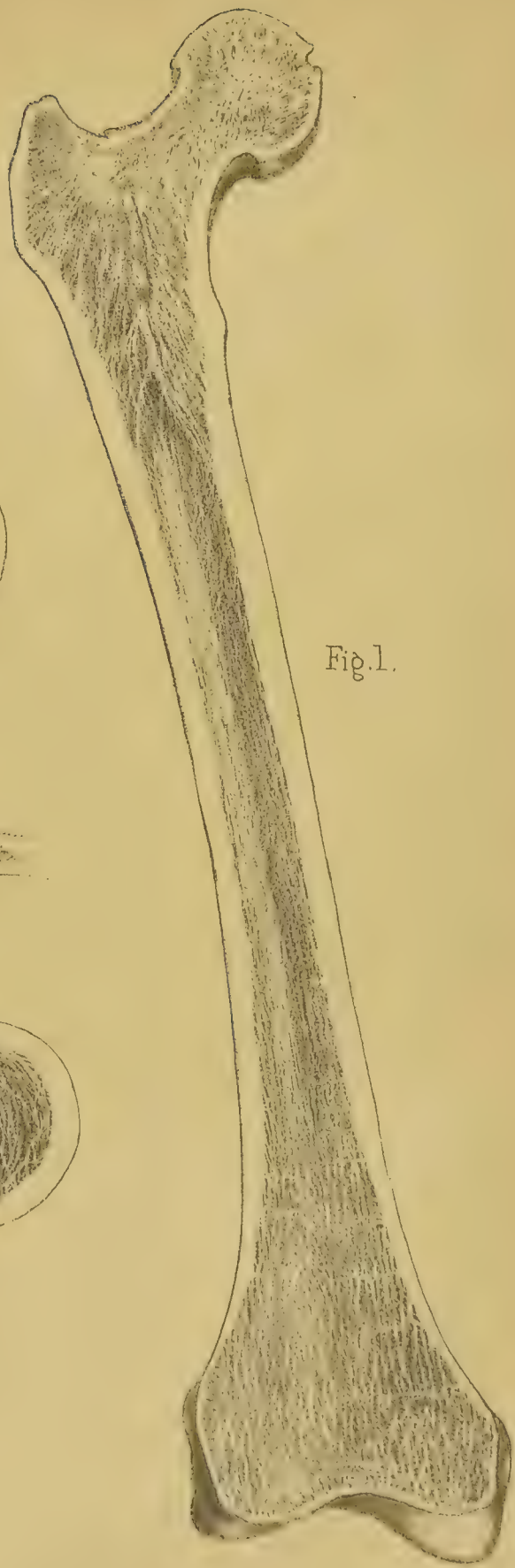


Fig. 1.

Fig. 2.



Fig. 4.

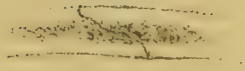
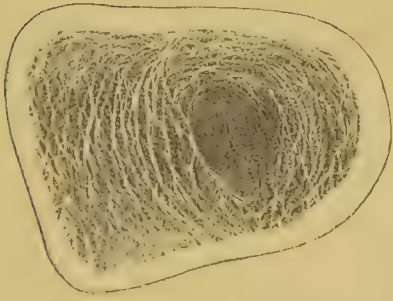


Fig. 3.



with a most delicate and elegant arrangement. The direction of this cancellous architecture in all parts of bones is arranged upon this principle:—its columns always run in the direction best adapted to support the pressure which the bone has to bear. A beautiful example of this is seen in the section of the cancellous tissue of the thigh-bone (Plate I.). At the lower part, towards the knee, the layers run vertically,—that is, in the direction of the axis of the shaft, this being the line of pressure when the body is erect. But in the neck of the thigh-bone the layers are arranged in decussating curves like the arches in Gothic architecture, one within the other, in order to sustain with the greatest mechanical advantage the weight transmitted on to the heads of the thigh-bones.

CANCELLOUS TISSUE. ITS STRENGTH AND PROPERTY OF BREAKING SHOCKS.

Though so light and spongy, the cancellous tissue is able to support a great weight without giving way. We may form some idea of its strength from the following experiment:—A cubic inch of cancellous texture was taken from the lower end of the femur, and placed with its principal layers upright. Four cwt. was then placed upon it, but it did not give way in the least. Six cwt. made it sink half an inch. Yet the cubic inch of bone itself did not weigh more than 54 grains. Not only is cancellous tissue strong as well as light, but it possesses also another advantage—that of breaking shocks. When one ball of ivory strikes another, as in the game of billiards, the whole force of the shock is transmitted from one to the other; but let a ball made of the cancellous tissue of bone be interposed, and then see how the shock will be broken. This property of breaking shocks is of course greater when the bone is in its natural state and filled with marrow.

The spaces formed by the cancellous tissue vary in size and shape, but freely communicate with each other, and with the holes on the surface of the bones. This communication is easily proved by boring a hole at one end of a bone, and pouring quicksilver into it:—we shall find that the quicksilver will run out freely through the natural holes at the other end.

MARROW, YELLOW AND RED.

The interior of the shaft of a long bone is filled with yellow marrow; a substance composed almost

* 'Outlines of Osteology,' by T. Ward, p. 368.

entirely of fat (96 per cent.); that is, in bones that are healthy. Like all other fat, it is removed in cases of great emaciation,—in general dropsy, for instance; and its place is supplied by an albuminous fluid. Hence the bones of a dropsical subject are always the least greasy, and the best adapted for skeletons.

But the cancellous tissue of the articular ends of

RED MARROW. long bones, and of the bodies of the vertebræ, the sternum, the ribs, and the bones of the cranium, contain another kind of marrow of a red colour. This red marrow differs from the yellow, in that it contains little or no fat,—not more than 1 per cent., according to Berzelius: it consists of water 75 per cent., and 25 per cent. of solid matters, chiefly albumen. It is this kind of marrow which is found in all the bones of the fœtus, and in infants. Hence it is sometimes called fœtal marrow. Examined with a high magnifying power, it is found to contain a number of oval, many-nucleated cells (Plate IV. fig. 9). We direct attention to these cells the more because they form one of the characteristics of a class of tumours termed ‘myeloid’ (*μυελωδής*, marrow-like), from their being chiefly composed of them; * morbid growths being in the present day named and classified as much as possible after their likeness to natural structures.

HOW BONES ARE SUPPLIED WITH BLOOD. At the articular ends of any long bone, or on the body of a vertebra, we observe a number of holes. Near the lower end of the thigh-bone we might soon count as many as 200 or more. What are these holes for? The smaller are for the transmission of the articular arteries for the nutrition of the cancellous tissue, which is exceedingly vascular. The larger are for veins which return by themselves. These veins of the cancellous tissue are large and numerous. They traverse and ramify through this tissue in various directions in special canals with thin walls of bone. They are well seen in a section through a vertebra (Plate V. fig. 7), also in the cancellous tissue (termed ‘diploe’) of the cranial bones. In a surgical point of view these ‘diploic’ veins are interesting, on account of their liability to inflame after severe injuries of the head: such inflam-

* ‘Lectures on Surgical Pathology,’ by Sir J. Paget, F.R.S.

mation may lead to suppuration in the diploe, which is often fatal. The adjoining cut shows the large venous canals in the 'diploe' of the skull-cap.

FIG. 4.



VEINS IN THE DIPLOE OF THE SKULL.

Again, on the outside of the shaft of a long bone there are a number of minute grooves, which run for the most part parallel to the shaft, and are for the lodgment of blood-vessels. At the bottom of these grooves lie a multitude of still more minute holes, barely visible to the naked eye, but easily seen through a small pocket-glass. These holes transmit the blood-vessels for the nutrition of the compact tissue, which come from the 'periosteum,' or membrane covering the bone. The marrow in the interior of the bone is supplied with blood by the 'medullary artery.' This artery reaches the marrow through a very distinct canal (canal for the nutrient artery of the medulla), which runs obliquely through the shaft, somewhere near the middle of it. In a long bone like the femur there are generally two of these, situated at the back part of it. As soon as the artery reaches the medullary cavity, it divides into an ascending and a descending branch, which ramifies for the supply of the marrow, and finally communicates with the 'articular' arteries already described.

Thus the several parts of a long bone are supplied with blood as follows:—The compact wall of the shaft by blood-vessels from the periosteum; the marrow in the interior by a special medullary artery; and the cancellous tissue of the ends by the articular arteries. The blood-vessels of these several parts are not exclusive, but communicate more or less with each other. Hence they readily reciprocate their morbid actions, and inflammation arising in the one part may spread to the other. Now, although these three orders of blood-vessels do communicate in the bone, yet we cannot

be surprised to find that when a bone is broken below the canal for the nutrient artery of the marrow, the lower fragment, being deprived of part of its supply of blood, in some cases becomes atrophied and thinner. Mr. Curling* has written an interesting paper on this subject; and a preparation is put up in illustration of it in the Museum of the College of Surgeons.†

PERIOSTEUM,
ITS USE.

FIG. 5.



BLOOD-VESSELS OF PERIOSTEUM.

Everywhere except at the insertion of strong tendons, and where covered with cartilage, the bones are invested with a tough fibrous membrane termed the periosteum. Its chief use is to provide a bed in which the blood-vessels may divide and subdivide, and so reduce themselves to a size small enough to penetrate the pores on the surface of the bones. The adjoining cut shows the arrangement of the blood-vessels of the periosteum. The periosteum likewise provides each of the vessels entering the bone with a fibrous covering. In foetal life it ministers to the formation of the bone, and ever afterwards to its nutrition. If, therefore, the periosteum be torn from the surface of a bone, there is a risk that a layer of the

subjacent bone will lose its vitality and be cast off.

MEDULLARY
MEMBRANE.
ENDOSTEUM.

The medullary canal and the cells (marrow spaces) of the cancellous tissue are lined by an extremely delicate membrane, termed the 'medullary,' or 'endosteum.' It is too delicate to be shown as a continuous membrane, like the periosteum; nevertheless, it supports the marrow, and provides a stratum for the subdivisions of the medullary artery, before they penetrate the contiguous bone.

Periosteum and bone unquestionably possess nerves. This is proved by absolute demonstration, and by disease. I have traced nerves into some of the minute foramina on the shaft of a long bone, and into the articular ends.

* 'Medico-Chir. Transactions,' vol. xx.

† 'Pathol. Cat.' vol. ii. Prep. No. 382a.

A nerve also enters the medullary canal with the nutrient artery of the medulla, and divides like the artery into an ascending and a descending branch. Of all the bones, the tibia presents the largest canal for the nutrient artery of the marrow; in this bone also it is easy to trace the entrance of the nerve with the artery. Though bone in health has but little sensibility, yet when diseased it becomes greatly exalted. There is such a thing as 'neuralgia' of bone. Every surgeon must have witnessed how sensitive are granulations from bone. Indeed, it is probable that the severe pain attendant on the ulceration of articular cartilage is occasioned by the pressure of the cartilage on the bone granulations beneath it.

LYMPHATICS OF BONE. The lymphatics of bone have been actually demonstrated by Cruikshank,* who succeeded in injecting the lymphatics of the body of a vertebra. Dr. A. Budgett has recently proved by injections that the blood-vessels of Haversian canals are surrounded by perivascular lymphatic vessels. This accounts for the fact that ivory pegs introduced into bones, for the purpose of consolidating ununited fractures, are in some instances absorbed.

MICROSCOPIC STRUCTURE OF BONE.

This is a most interesting and instructive study. It reveals to us that bones are as minutely provided with blood-vessels and nerves, and in all respects as much cared for, as the softer parts of the body. Being as fully organised as other parts, we cannot wonder that they are subject to the same diseases. We have to investigate how the bones are formed in early life, how they grow to maturity, how their health is maintained, how their injuries are repaired. Would anyone, looking at a solid bone, expect to find that even its hardest parts are tunnelled out by a network of minute canals for the passage of blood-vessels; and that from these canals other tubes, infinitely more minute, and connected with a series of reservoirs, radiate in all directions for the purpose of nutrition?

**GENERAL IDEA
OF THE SUBJECT.**

Let us first get a general idea of the microscopic structure of bone, and go into details

* 'Anatomy of the Absorbent Vessels,' 1790, p. 198.

† 'Archiv f. Microsc. Anatomie,' bd. xiii.

afterwards. If a transverse section from the shaft of a long bone be ground extremely thin, and examined with a power of about 20 diameters (Plate II. fig. 4), we see a number of holes, with dark spots grouped round them, in a series of tolerably concentric

Haversian circles. These holes are sections of the canals **Canals.** (termed 'Haversian,' after their discoverer, Clopton* Havers *) which transmit blood-vessels into the substance of the bone. The dark spots are minute reservoirs, called 'lacunæ.' They look like solid bodies, but they are cavities and are occupied during life by soft 'bone corpuscles,' concerning which more will be said hereafter. As we examine the different parts of the section we notice that the Haversian canals vary considerably in size and shape. They are generally round or oval. Those nearest to the circumference of the bone are very small; but towards the medullary cavity they gradually grow larger, and at last open out into the cells of the cancellous texture.

Haversian Let us now examine the same section with a **Lamellæ.** higher power (Plate II. fig. 6), and we shall find that the Haversian canals are surrounded by a series of concentric lines, reminding us of the transverse section of the branch of a tree. These lines are termed the 'lamellæ.' They are so many layers or rings of bone that have been developed within the Haversian canal. Understand that even the smallest Haversian canal was, when originally formed, a much wider space, and circumscribed by only a single layer of bone; but in process of growth the canal becomes gradually contracted by the deposit of successive layers of bone. We notice also that the dark spots, before alluded to as the 'lacunæ,' are situated between the lamellæ, and that now, under a higher magnifying power, they look like insects. The central part of the lacuna, representing the body of the insect, is hollow, and the dark filaments which run out from it, representing the legs, are minute tubes termed 'canaliculi.' These are exceedingly numerous, and radiate from all parts of the 'lacuna,' through the lamellæ. Now since the canaliculi of one circle of lacunæ communicate most freely with those of the next circle, and the canaliculi

* An English physician of the seventeenth century.

Fig. 1.

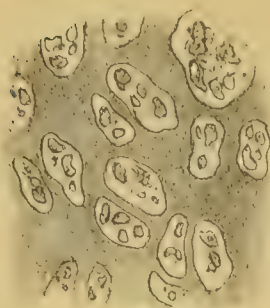
200 dia^s



Fibro cartilage.

Fig. 2.

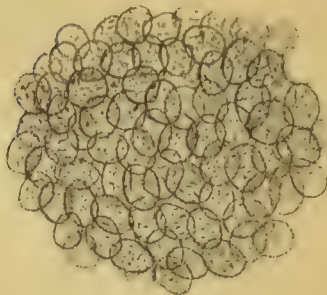
250 dia^s



Hyaline cartilage.

Fig. 3.

200 dia^s



Cellular cartilage

BONE..

Fig. 4.

20 dia^s

Haversian canals.

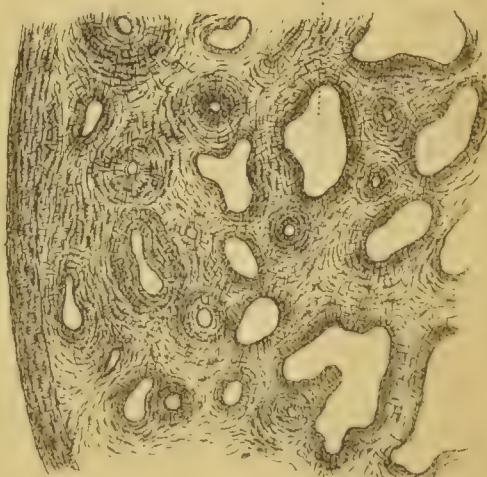


Longitudinal section of
Haversian canals

Fig. 5.

20 dia^s

Haversian canals

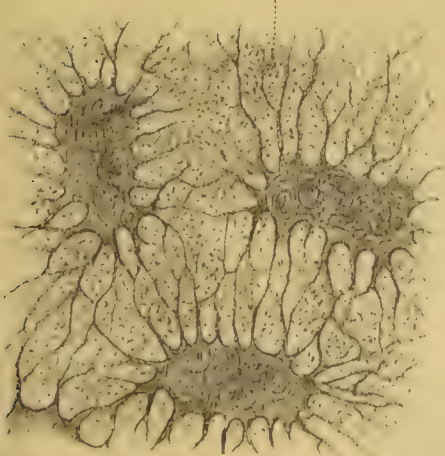


Transverse section of
Haversian canals.

Fig. 6.

1200 dia^s

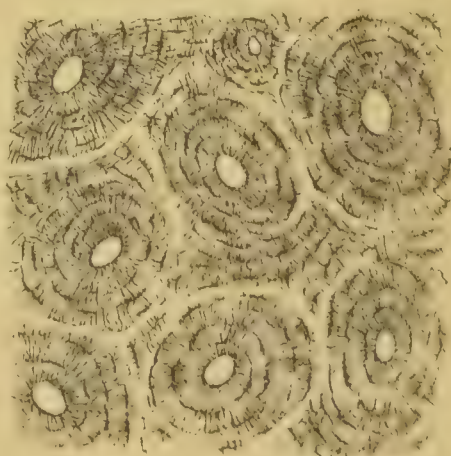
Osseous granules.



Lacunæ and Canaliculi highly magnified.

Fig 7

100 dia^s



Haversian systems.

nearest to the Haversian canal open directly into it, we see that by means of this system of radiating tubes a complete communication is established between the Haversian canal in the centre, and the successive circles of bone which surround it. The nutrient material of the bone proceeds from the blood-vessels in the central canal, and is transmitted through the canaliculi from one lacuna to another.

**WHAT IS AN HA-
VERSIAN SYSTEM?** Every Haversian canal taken in conjunction with its concentric layers of bone, lacunæ, and canaliculi, is termed an ‘Haversian system.’ (Plate II. fig. 6.) It may be compared to the planetary system. As the sun is the centre of light and heat to the planets around it, so is the blood-vessel in the Haversian canal the centre of nutrition to the surrounding circles of bone.

Almost all the compact substance of bone is made up of a multitude of these ‘Haversian systems.’ Each system is, to a certain extent, independent of its neighbour, since the lacunæ of one system communicate very sparingly with those of another. In consequence of this isolation, we sometimes find, in favourable sections, that each system is more or less circumscribed by a tolerably distinct white line, which is transparent bone with but few canaliculi.

**HAVERSIAN
INTERSPACES.** As the Haversian systems are for the most part circular, and arranged like sticks in a faggot, it is clear they cannot touch each other in all parts of their circumference; so that here and there we observe that triangular portions of bone fill up the gaps between them. Such portions are termed ‘Haversian interspaces.’ (Plate II. fig. 4 *b*.) These ‘outlying’ portions of bone are also provided with lacunæ and canaliculi, and they derive their nourishment from the surrounding Haversian systems, of which they are, so to speak, dependencies.

The section we have hitherto been examining was a transverse one. We must now make an equally thin section in the longitudinal direction of the shaft, and we then have quite a different appearance (Plate II. fig. 3). We cut in the course of the Haversian canals, not across them; and we find that, as a general rule,

they run parallel to the surface of the bone (no matter whether long or flat), and that they communicate very frequently by transverse or more or less oblique canals. If the section be large enough to include the Haversian canals near the circumference, we find that many open on the outer surface so as to admit blood-vessels from the periosteum; others, again, open into the medullary canal, to admit blood-vessels from the interior. In this way the Haversian canals permeate the compact substance of the bone, and establish a free communication between the blood-vessels of the periosteum and those of the medulla. These canals may, in fact, be regarded as so many multiplications of surface for the ramifications of blood-vessels in order that no part of the bone substance may be beyond the range of nutrition.

In this longitudinal section, the lamellæ, instead of being arranged concentrically, are seen running in lines parallel with the Haversian canals to which they belong.

BONE TISSUE.

At this stage of the investigation, a question naturally arises—Where is the earthy material, the phosphate and carbonate of lime? To see this, the transverse section must be magnified about 1,200 diameters (Plate II. fig. 5). We then discover that the earthy ingredient consists of an infinite multitude of minute osseous granules, which are deposited in a ‘matrix’ or bed of animal matter. This mixture of earthy granules and animal matter we call ‘bone tissue.’ It occupies all the space between the lacunæ and their canaliculi. If the specimen were steeped for a time in dilute hydrochloric acid, the osseous granules would be dissolved out of it, and the little pits in the matrix in which the granules were imbedded would become apparent.

So far we have acquired a general notion of the minute structure of bone; that is to say, of the ‘Haversian canals,’ the ‘lacunæ’ and their ‘canaliculi,’ the ‘lamellæ,’ and the ‘osseous granules.’ We must now speak of these several parts a little more in detail; and first, of the Haversian canals.

HAVERSIAN CANALS.

As said before, the Haversian canals are tunnelled out of the compact substance of the bone, for the purpose of conveying blood-vessels for its nutrition.

Observe, they form no part of the *essential* structure of bone. Wherever bone is so thin as to be able to derive its nutrition from the vascular membrane covering its surface, we do not find Haversian canals in it, nor does it require any. For instance, the delicate plates of bone composing cancellous tissue, the paper-like bones in the interior of the nose, have no Haversian canals in them; but they have plenty of lacunæ, which send out their canaliculi to open on the surface and imbibe the requisite nutrition. Bone so thin as to need no Haversian canals is called ‘non-vascular’ bone. Such bone lives upon the blood which flows through the minute vessels of its periosteum. Bone has, therefore, like all other living structures, a *self-formative* power, and draws from the blood the materials for its own nutrition.

THEIR DIAMETER.

The Haversian canals vary in diameter from $\frac{1}{1000}$ to $\frac{1}{200}$ of an inch, the average being about $\frac{1}{500}$. The smallest are found near the outer surface, where the bone is the most compact; but they gradually become larger towards the interior, where they open out into the cancellous tissue, or into the medullary cavity. All, whatever their direction may be, are surrounded by concentric lamellæ of bone; but the number of the lamellæ varies round different canals from 5 to 15 or more; a smaller number in young bone, and a larger in old. All of them are lined by a very delicate membrane, continuous with the periosteum. The smallest canals contain only a single capillary blood-vessel; the larger contain a network of vessels, while the largest, which gradually merge into the cancellous tissue, contain marrow as well as blood-vessels.

THEIR LINING
MEMBRANE.

THEIR CONTENTS.

Here it may be as well to mention a fact concerning the minute structure of bone, which should never be lost sight of. It is this:—that everywhere underneath the membrane in contact with the surface of bone, whether it be the periosteum covering the exterior, the prolongation of it lining the Haversian canals, or the medullary membrane (endosteum) lining the cancelli, there is a delicate layer of soft connective tissue, with a multitude of small corpuscles in it, termed ‘*osteoblasts*.’* Now, it has been ascertained that

* From *ὀστέον* bone, and *βλάστος* a bud.

these osteoblasts, and the soft tissue in which they are imbedded, are mainly concerned in the formation and the growth of the bone; and that by the successive ossification of these tissues, the concentric layers of bone are produced within the Haversian canals.

DILATATION OF
HAVERSIAN
CANALS FROM
INFLAMMATION.

The knowledge of the free circulation of blood through the substance of bone gives us the key to some of the effects produced by inflammation in it. For example, as inflammation in soft parts is attended by dilatation of the blood-vessels, so is it in the case of bone. When bone is actually inflamed, the blood-vessels in the Haversian canals become greatly enlarged, and cause the

FIG. 6.



SEPARATION OF LAYERS BY
INFLAMMATION.

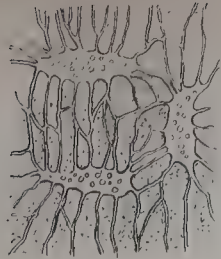
canals themselves to become larger by absorption of the bone tissue,—so much so as to give the bone, sometimes, a reddish colour. In operations where the surgeon has to cut through inflamed bone, one may see the blood flowing from the cut surface of the bone, as it would from the soft parts. More than this, the distended blood-vessels may occasion not only a gradual enlargement of the Haversian canals, but their inflammatory deposit may cause even a general swelling of the compact substance of the bone and a natural separation of its component layers, so that it becomes light and spongy, as seen in the adjoining cut.*

THEIR OBLITERATION IN SOME
CASES.

On the other hand, under certain circumstances of long-standing disease, *e.g.* chronic inflammation, we sometimes find that bones become harder and thicker than natural. They may become as hard as ivory, and can take a polish. Here the Haversian canals are nearly filled up by successive layers of bone. Indurated bone is therefore less vascular than healthy bone. A good example of ‘eburnation’ of bone is occasionally seen as the result of chronic osteo-arthritis, where the articular ends of bone lose their cartilage and become hard and polished like ivory, owing to the blocking up of the Haversian canals by osseous tissue.

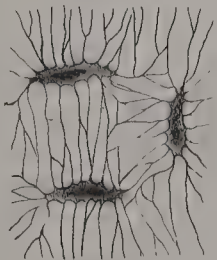
* From a preparation in the Museum of St. Bartholomew's Hospital.

Fig. 4.

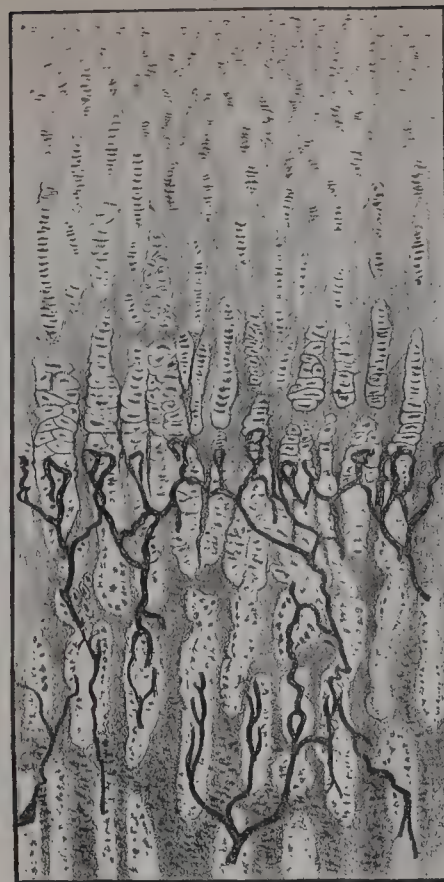


Lacunæ and Canaliculi.

Fig. 5.

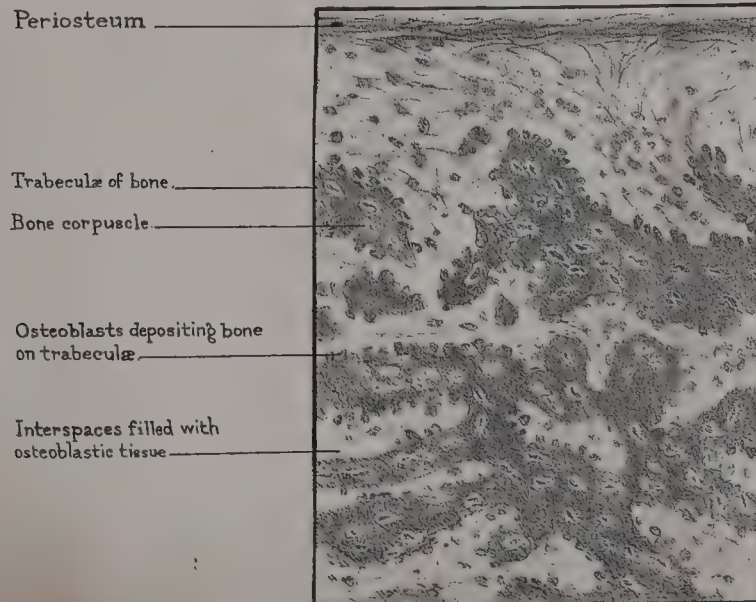


Bone corpuscles and their processes which occupy the lacunæ and canaliculi of fig. 4.



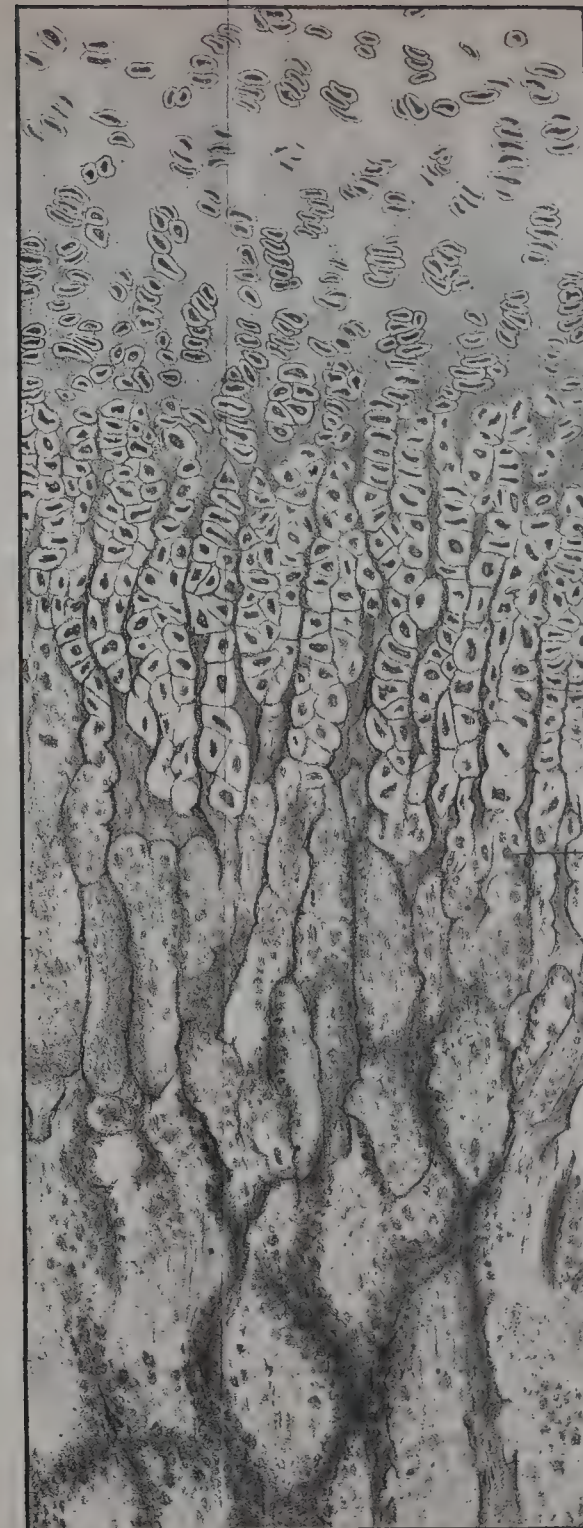
Section of ossifying cartilage, showing the loops of blood vessels.

Fig. 3.



Section of a young parietal bone.

Fig. 1.



Hyaline cartilage.

Cartilage cells enlarged and arranged in rows, separated by calcified matrix.

Osteoblasts replace the cartilage cells. Formation of medullary spaces.

Trabecular remains of calcified cartilage coated with thin layer of bone.

The layers of bone thicken as calcified matrix becomes absorbed.

Vertical Section of ossifying cartilage at the Epiphysis.

LACUNÆ CHARAC-
TERISTIC OF TRUE
BONE. THEIR
CONTENTS.

The 'lacunæ' are the insect-like cavities which we find between the lamellæ, arranged in concentric circles round the Haversian canals. They are characteristic of true bone, and distinguish it from 'calcifications,' sometimes met with as products of disease. Formerly the lacunæ and canaliculi, in consequence of their dark colour, were considered to be solid; but later observations have proved them to be hollow. Each lacuna in the living bone contains a soft nucleated substance termed a 'bone corpuscle,' which sends its soft processes or 'outrunners' along the canaliculi, and of which the function is to circulate nutritious matter through the bone.* Such a bone corpuscle with its processes highly magnified is shown in Plate III. fig. 5.

As a rule, the lacunæ are oval and flattened, so that one of their broad sides may be turned towards the Haversian canal. The first ring of lacunæ sends half of its canaliculi directly into the Haversian canal, while the other half communicates with the canaliculi of the second ring, and so on throughout the whole system. The nutrient fluid, or 'plasma,' of the blood, exuding through the coats of the blood-vessel in the Haversian canal, is imbibed by the inhabitants of the nearest row of lacunæ, and passed on to all the others in the Haversian system. One may say, then, that the lacunæ are parts of the machinery of nutrition for the bone.

THEIR SIZE
AND SHAPE.

In man, the lacunæ measure about $\frac{1}{2000}$ of an inch in their long diameter, and about $\frac{1}{6000}$ in their short. It has been shown by Mr. Quekett that they vary in size and shape in the four great classes of animals, so that by means of this test it can be ascertained with certainty whether a given fragment of bone be part of a mammal, a bird, a reptile, or a fish. As this test is equally applicable in the case of fossil bones, it has an important bearing upon the study of geology. Another interesting fact discovered by Mr. Quekett is, that the size of the lacunæ bears very little relation to the size of the animal

* The lacunæ and canaliculi can be filled with Canada balsam. It is curious that in the bones of bodies embalmed, these minute cavities are filled with the bituminous material.

to which they belong. They are nearly as large in the bones of the little lizard as they are in those of the enormous extinct lizard, the *Iguanodon*. But their size *does* bear an exact proportion to that of the blood corpuscles in the several classes of animals. Therefore, as reptiles have the largest blood corpuscles, so have they the largest lacunæ.

CANALICULI : Respecting the 'canaliculi' (Plate II. fig. 5),
THEIR SIZE AND observe how exceedingly minute they are; that
OFFICE. they run off from all parts of the circum-
ference of the lacunæ, and communicate most freely with the
canaliculi of the adjoining lacunæ. Their diameter ranges from
 $\frac{1}{14000}$ of an inch to $\frac{1}{20000}$ of an inch; but there are some even
smaller. They are far too small to allow the entrance of blood
cells. They admit the passage of nothing but the fluid part of
the blood, the 'plasma,' destined to nourish the bone and keep it
in a state fit for self-repair when injured by disease or violence.

LAMELLÆ. In man, and almost all mammalian animals,
bone grows by the deposit of fresh layers. In all
cases the new layer is deposited on that surface of the old layer
which is next to the blood-vessel. Therefore, in a fully formed
Haversian system, we get the appearance of 'concentric' rings.
They vary in thickness from $\frac{1}{3000}$ to $\frac{1}{5000}$ of an inch. Those
around the Haversian canals vary from five to fifteen in number,
and are called the 'Haversian lamellæ.' Those surrounding the
circumference of a long bone which has reached its full growth are
termed 'circumferential lamellæ.' (Plate II. fig. 4 *a*.) The ill-
defined and broken layers apparent here and there in the Haver-
sian interspaces are termed 'interstitial lamellæ' (Plate II. fig. 4 *b*).
It seems doubtful how these interstitial lamellæ were originally
formed; but the investigations of Messrs. Tomes and De Morgan*
led them to believe that they are the remnants of Haversian
systems that have been partially removed by absorption.

NAILS (CLAVICULI) In carefully made preparations of decalcified bone,
OF GAGLIARDI. it may be seen that its constituent lamellæ are con-
nected by fibres which perforate them either at a right or an oblique
angle, and thus 'bolt' them together. These 'perforating fibres' or

* Philosophical Transactions, 1853.

bolts appear to answer a mechanical purpose. They are best shown by separating the lamellæ. Thus you see not only some of the bolts pulled out, but also the holes through which they passed. This beautiful fact in the minute anatomy of bone was first described by Domenico Gagliardi, a distinguished professor of medicine at Rome in the seventeenth century. It is true that he only examined the dry bones. But he describes and draws with such truthfulness their lamellar structure and their connecting little 'nails' (claviculi), and adds so many original reflections, that his work* is quite worth the notice of modern anatomists.

OSSEOUS
GRANULES.

The earthy salts are deposited in the animal matrix in the form of exceedingly minute granules. The Germans call them 'bone crumbs.' We cannot see them, however, without a magnifying power of 1,200 diameters (Plate II. fig. 5). They vary in size in different specimens of bone. In man their size ranges from $\frac{1}{6000}$ to $\frac{1}{14000}$ of an inch. They can be very distinctly seen in the skulls of small birds—the canary, for instance—and also in the skull of the bat, where they are so much larger than in the human subject. After a section of bone has been steeped for some time in dilute hydrochloric acid, these earthy particles will be dissolved out of the animal matrix, and the little cavities in which they are imbedded can then be distinctly seen.

PRESENT IN
PUS COMING FROM
DEAD BONE.

It is an interesting and valuable practical fact, that these earthy granules are generally present in the pus which comes from dead bone. If a specimen of pus under such circumstances be examined with a power of 500 diameters, a number of earth granules may be detected among the pus cells, proving that there is a dead bone somewhere. Mr. Quekett noticed this fact many years ago. Mr. Bransby Cooper has also ascertained that in pus coming from diseased bone there is as much as two and a half per cent. of phosphate of lime.

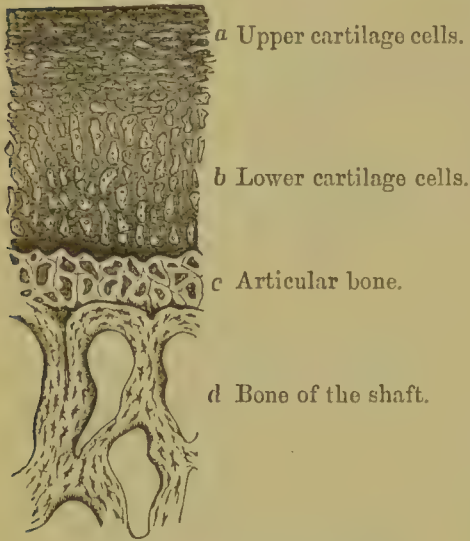
ARTICULAR BONE:
ITS PECULIARITIES.

By this we understand a thin layer of bone situated immediately under articular cartilage;

* 'Anatome ossium novis inventis illustrata.' Romæ, 1689, in 8.

and since there is a peculiarity about the structure of it we will allude to it here. If a perpendicular section be made through the articular surface of any fresh bone with the cartilage attached, it will be observed (as seen in fig. 7) that the cartilage does not rest immediately upon the cancellous tissue of the bone, but upon a thin compact crust of bone which closes the cancelli. This crust, which we call 'articular bone,' varies in thickness, and is of a

FIG. 7.



STRUCTURE OF ARTICULAR BONE.

remarkably white colour. But its chief peculiarity consists in this,—that it has no Haversian canals, and therefore is not vascular. The blood-vessels of the cancellous tissue run up only as high as its under surface, and then turn back in loops. Moreover, its 'lacunæ' are three or four times larger than in ordinary bone, and are destitute of canaliculi. Here is a striking instance of design. This layer of bone, having no Haversian canals, is much less

porous than common bone, and in consequence of its closer texture is all the stronger, and more adapted to form an unyielding surface for the support of the articular cartilage.

Although articular bone and adult articular cartilage have no blood-vessels in health, yet they both become vascular in some cases of disease of the cartilage. Blood-vessels may be seen, when successfully injected, shooting up through the heretofore non-vascular layer of bone into the cartilage on its surface.

STRUCTURE OF CARTILAGE.

VARIETIES OF CARTILAGE.

Cartilage, commonly called gristle, is tough, flexible, very elastic, of a greyish white colour, and used for various purposes in the animal body. There are many kinds of it. The simplest kind, when examined with the microscope, is found to consist of a mass of nucleated cells, closely

CELLULAR CARTILAGE. packed and variously shaped from mutual pressure. Such cartilage as this may be seen in a tadpole, or in the spinal cord of a lampren, or in the ear of a bat or mouse (Plate II. fig. 3). Under the microscope, though not to the naked eye, it is like some kinds of vegetable tissue; for instance, the pith of the elder.

Another kind of cartilage, and that which chiefly concerns us, consists of nucleated cells (cells with nuclei in their interior) of various shapes, not packed closely, but imbedded in a matrix of a homogeneous substance, termed 'intercellular.' It is altogether a much firmer kind of cartilage. Now the nature of this inter-

HYALINE CARTILAGE. cellular substance varies. It may be clear and transparent like glass: then we call it 'hyaline cartilage' (fig. 2). Of this kind is the foetal skeleton, and the white cartilage covering the articular ends of the bones. Or the intercellular substance may contain fibrous tissue: then we call it **FIBRO-CARTILAGE.** 'fibro-cartilage' (fig. 1). This kind of cartilage is found in connection with certain joints.

In the gristle of the nose and the ear we have another variety, containing elastic fibres, and known as 'yellow' or 'elastic cartilage.'

PERICHONDRIUM. All kinds of cartilage, with the exception of that which covers the ends of the bone (articular cartilage), are invested with a white fibrous membrane, termed 'perichondrium.' This, like the periosteum of the bones, serves to support the nutrient blood-vessels of the cartilage. When the cartilage is thin, the vessels proceed no farther than the surface; but when it is thick they are prolonged into its substance by means of canals, carrying with them a sheath of perichondrium.

Articular cartilage has no perichondrium, neither has it blood-vessels, except in the young condition. But when diseased, it has been proved by injection* that blood-vessels do shoot into the cartilage through the layer of articular bone beneath it.

CARTILAGINOUS SKELETON. The parts of the embryo destined to become bone may be detected as early as the seventh

* See 'Catalogue of the Histological Series' in the Museum of the R. C. S. E., vol. i. Plate VIII. fig. 11.

week after conception, as a gelatinous pulp without trace of organisation, contained in a delicate membrane. Presently this pulp becomes converted into the simplest form of cartilage,—that is, an aggregation of closely-packed nucleated cells. But since a mere aggregation of soft cells would not be a sufficient basis of support to the surrounding parts in progress of development, intercellular substance is added to give it greater solidity, and this ‘cellular’ cartilage becomes ‘hyaline’ cartilage. Thus the entire skeleton of the foetus, with the exception of the skull-cap and the bones of the face, consists at first of hyaline cartilage.

The deposition of bone does not take place at the same time in all parts of the cartilage, but at certain points, which are called ‘centres of ossification.’ Every bone has a definite number of these centres, which always appear in the same place; and from these centres the ossification extends according to a regular plan. The number of centres varies in different bones. Some bones have only a single centre; others two, three, five, seven, etc.; and the bone called the ‘sacrum’ has as many as thirty-three centres before its ossification is complete.

Observe, the centres of any given bone do not all appear at once; some appear before birth, others after it, but all in regular succession, and at stated periods, according to the degree of importance of the bone, and the function which it has to perform; *e.g.* the lower jaw and the ribs ossify early, because suction and respiration are brought into play at birth. As a general rule, each centre appears first in the middle of the cartilage; and thence the ossification extends towards the circumference in the flat bones, and towards the extremities in the long bones. Almost all the bones, then, in infancy and childhood are made up of so many distinct bony pieces united together by cartilage; and these several pieces remain distinct until the stature of the individual is complete, after which they are all consolidated.

OSSIFICATION OF
THE THIGH-BONE
SELECTED AS AN
EXAMPLE.

As an example of what can be seen of the process of ossification with the naked eye, let us follow out that of the thigh-bone (Plate IV. figs. 1 to 6). The future bone is at first sketched out in hyaline

cartilage. About the beginning of the third month after conception, the first centre of ossification appears in the middle of the shaft—as is the case in all the long bones (fig. 1). From this point ossification gradually extends up and down the shaft, which is all ossified before the other centres appear. About the last month of foetal life, a second centre appears in the lower end, which forms the knee (fig. 3). About the end of the first year after birth, a third centre appears at the upper end or head of the bone (fig. 4). In the course of the fourth year, a fourth centre appears in the projection termed the ‘trochanter major’ (fig. 5). In the course of the fourteenth or fifteenth year a fifth and last centre appears in the ‘trochanter minor’ (fig. 6).

MEANING OF
‘DIAPHYSIS’ AND
‘EPIPHYSIS.’

Thus, then, the thigh-bone has five centres of ossification. The shaft or body of the bone, which ossifies first, is called the ‘diaphysis;’ the other parts are termed ‘epiphyses.’* As these epiphyses, during the period of growth, are only united to the shaft by a layer of cartilage, the separation of an epiphysis by violence is not an unfrequent accident in childhood. When growth is complete, all the epiphyses are consolidated with the rest of the bone, and no cartilage remains except at the articular surfaces, where there is a thin layer of it to break the shocks at the joints.

ORDER IN WHICH
THE EPIPHYSES
UNITE TO THE
SHAFT.

It is worth observing, concerning the union of the articular epiphyses at the ends of the long bones, that the epiphysis of that end towards which the canal for the medullary artery runs, always unites to the shaft before the epiphysis at the other end.

It is a curious fact, also, that the order in which the epiphyses unite to the shaft of a bone is just the reverse of that in which they begin to ossify. Thus, the epiphysis of the trochanter minor, though ossifying last, unites first. The same may be said of the trochanter major, of the head of the femur, and, lastly, of the lower end. At the age of twenty-one, or near it, they have all united to form a single bone.

* An ‘epiphysis,’ therefore, is a portion of bone growing *upon* another, but separated from it by cartilage.

FINAL PURPOSE
OF DEVELOPMENT
FROM SEVERAL
CENTRES.

The fact that bones are developed from several ossific centres, separated by layers of cartilage, has for its final purpose the well-being of the growing animal. For example, it is necessary to have one part of a bone ossified to support weight, while other parts remain cartilage to take off concussion. 'The young lamb or foal,' to use the words of Professor Owen, 'can stand on its four legs as soon as it is born; it lifts its body well above the ground, and quickly begins to run and bound. The shock to the limbs themselves is broken and diminished at this tender age by the division of the supporting long bones,—by the interposition of the cushions of cartilage between the diaphyses and the epiphyses.' The nervous system of slow and cold-blooded animals, whose limbs sprawl outwards, and whose bodies trail upon the ground, does not demand such protection. Therefore we do not find epiphyses, with cushions of cartilage, at the ends of the shafts of the long bones of saurians and tortoises. But when the reptile moves by leaps, then the principle of ossifying the long bones by distinct centres again prevails, and the extremities of the humeri and femora long remain epiphyses in frogs.

We see, moreover, a definite purpose in separate centres of ossification for the bones of the head, not only as facilitating growth, but also the process of birth. The bones of the skull-cap, being connected only by membrane, can overlap each other a little during parturition.

WHAT BONES
ARE DEVELOPED IN
MEMBRANE.

Most of the bones in the human body pre-exist in the shape of cartilage, and form what is called the 'cartilaginous skeleton,' for the support of the embryo. But there are some bones which do not pre-exist as cartilage, and are formed directly in membrane, namely, the bones of the skull-cap (the frontal bone, the parietal, the upper half of the occipital, the squamous and tympanic parts of the temporal); also, the bones of the face; and lastly, the inner plate of the pterygoid process of the sphenoid.* In short, none

* The internal pterygoid plate of the sphenoid, although in the human subject it unites about the seventh month with the external, remains separate in other animals, and is called the 'pterygoid bone' in comparative anatomy.

of the bones of the skull pre-exist as cartilage, except those which form the base of the skull. The base is sketched out in cartilage at a very early period of foetal life, to form a support for the young brain. The cap of the skull, at the time we are speaking of, is simply membranous.

OSSIFICATION IN MEMBRANE. We will examine first what can be seen of the formation of bone in membrane with the naked eye, taking the parietal bone as an example. In the early embryo, the covering of the brain is composed of two closely united membranes—an outer, termed the ‘pericranium’; and an inner, termed the ‘dura mater’: between these the bone is laid down. About the end of the second month after conception, a centre of ossification appears in the middle of the space which is to be occupied by the parietal bone. From this centre the deposition of bony matter radiates in the form of fibres (Plate IV. fig. 7). Similar centres of ossification appear simultaneously in other parts of the soft covering of the brain, and, radiating in the same manner, sketch out the rudiments of the several bones of the skull-cap. For some time the individual bones are connected simply by membrane; and even at birth they can overlap each other a little, in order to facilitate parturition. Long after birth, indeed, there are parts of the skull-cap closed in by membrane only, as everyone knows who has felt the head of an infant (Plate XXVII. fig. 4). These unossified parts are called the ‘fontanelles,’ from the visible pulsations of the brain beneath them, like the bubbling of a spring. As the child grows, the rays from the edges of the bones meet and dovetail so as to form what are called the ‘sutures.’ For a long period of life the sutures may be separated; indeed, a thin film of animal matter is left unossified between the interlocking teeth of the bone, of which the manifest design is to break the shock of a blow on the cranium. As old age creeps on, even this film of animal matter ossifies, and the cap of the skull becomes a solid dome of bone, with all trace of the sutures lost.

MICROSCOPIC EXAMINATION OF OSSIFICATION IN MEMBRANE. Let us now study what can be seen with the microscope of the process of ossification in membrane, taking that of the parietal bone as an example.

The membrane or animal basis to be ossified is composed of

BONE-BUILDING MATERIALS. fibres like those of common connective tissue. The fibres interlace freely and the meshes between them are filled with blood-vessels and closely packed granular corpuscles termed 'osteoblasts.' These are all the materials required for bone building.

CHANGES IN THE MEMBRANE. The centre of ossification is at the (future) parietal eminence. Just before the appearance of the bone salts, the membrane becomes thicker and more vascular. Its component fibres radiate in thicker bundles from the centre towards the circumference sketching in advance the lines in which the bone is to be laid. Meantime the 'osteoblasts' have enormously multiplied.

OSTEOBLASTS AND THEIR FUNCTION. The 'osteoblasts' (bone beds or germs) are granular nucleated corpuscles about the size of the white corpuscles of the blood. They are so named because they and their descendants are believed to take most important

parts in the actual formation of bone. It is probable that they are not all destined to a like future. But one of their chief functions appears to be to abstract from the blood the bone salts, to lay them in and around the fibres of the membrane, and to become themselves ossified, and blended in the fabric of the bone, like the bricks of a building.

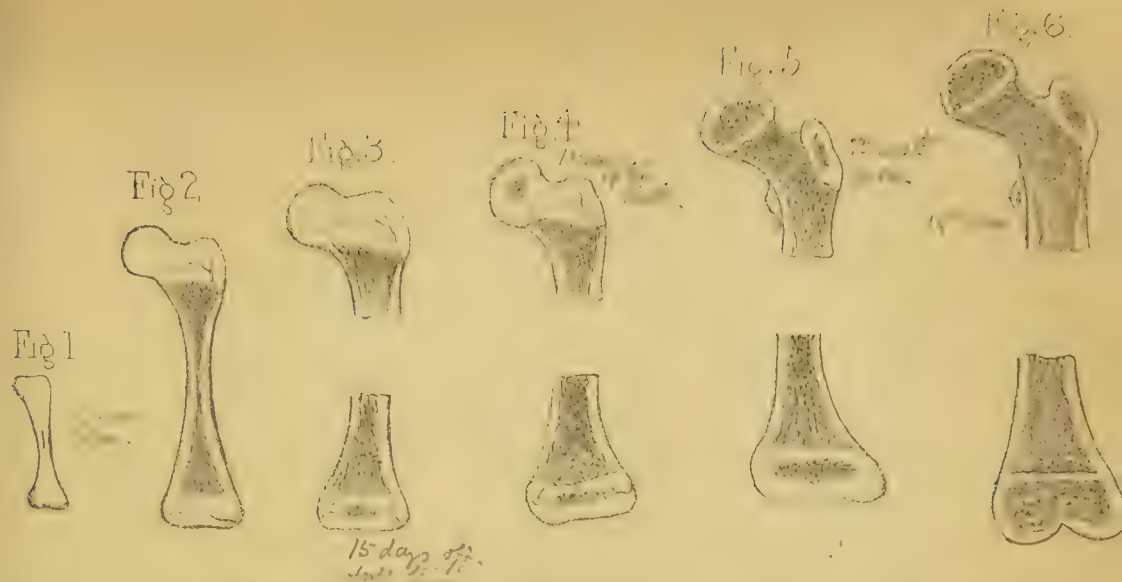
FIG. 8.



DIAGRAMMATIC SKETCH OF PART OF AN OSSIFYING PARIETAL BONE OF A FOUR MONTHS' FETUS. (FROM A PREPARATION IN THE MUSEUM OF THE R. C. OF SURGEONS.)

GROWTH OF THE BONE IN EXTENT. From the centre of ossification the deposit of bone shoots out in needle-like rays (trabeculae) towards the circumference, as shown in the annexed wood-cut (fig. 8). Under a high power the rays of bone can be seen covered with layers of osteoblasts, which successively ossify, and thus the bone grows in extent. The

best place to see the process is at the points of the rays where the membrane is more or less transparent. The dark rays may be



Diagrams showing the formation of the Thigh bone

Time of all parts by 2 years old

15 days off.

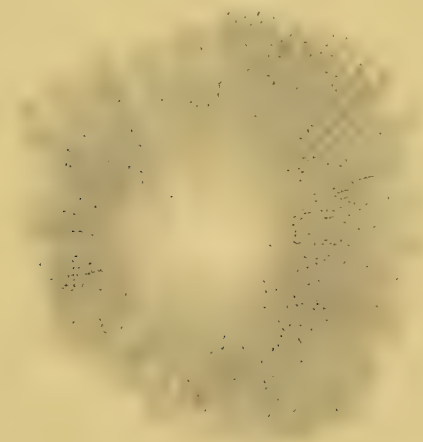


Fig 7.

Parietal bone of a Fetus.



Cells from Foetal marrow.

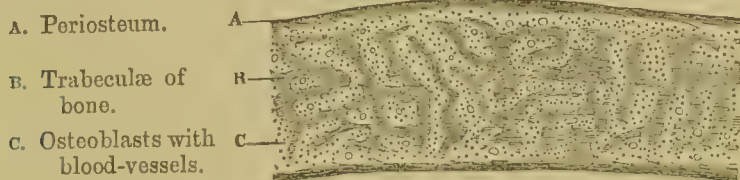


Section of Foetal bone.

seen advancing amongst the crowd of osteoblasts, and some of the osteoblasts in progress of ossification upon the rays.

GROWTH IN THICKNESS. To see how the bone grows in thickness, a section should be made across the rays where they are a little thicker. Such a section (fig. 9) shows that the rays

FIG. 9.



VERTICAL SECTION THROUGH AN OSSIFYING PARIETAL BONE.

become connected by cross arches, and thus form channels for the blood-vessels and bone-building materials. These channels are the Haversian canals. Some of them remain as cancellous tissue; others are gradually filled by the ossification of concentric layers of osteoblasts and become Haversian systems. (Plate IV. fig. 8.)

ORIGIN OF THE BONE CORPUSCLES. The interesting but difficult question as to the origin of the bone corpuscles and their connecting processes has been for many years under discussion. But the now generally accepted doctrine is, that they are developed from some of the osteoblasts. It has been already observed that the osteoblasts have probably not all the same future. It is the destiny of some to become ossified. It may be the destiny of some to become marrow cells: while others are destined to be developed into bone corpuscles, and perform their allotted functions shut up in their bony crypts (*lacunæ*) and their connecting processes in bony tubes (*canaliculi*). The evidence of this development of osteoblasts into bone corpuscles is derived from the fact that some of them can be seen in the successive stages of their transformation.

PROCESS OF OSSIFICATION IN CARTILAGE. We will now endeavour to explain that the process of ossification in cartilage, rightly understood, is essentially like ossification in membrane. In both cases the materials for bone building are similar, namely, connective tissue, blood-vessels, and the little corpuscles termed 'osteoblasts.' The old school used to teach that the cartilage was

directly transformed into bone tissue. But this is not the modern doctrine. The microscope has proved that the cartilage is only a temporary structure, that, having answered a temporary purpose, it is removed, and that true bone tissue, of which the materials are derived from the periosteum, is substituted in its place as a new product.

CHANGES IN THE CARTILAGE.

Previous to its removal the cartilage undergoes remarkable structural changes, of which the object seems to be to prepare the way for the coming bone and to shape the direction in which it is to be laid. These preparatory changes are—the enlargement of the cartilage cells, their arrangement in columns (especially at the epiphysial end), and the calcification of the intervening matrix.

DIFFERENCE BE- TWEEN CALCIFICA- TION AND OSSIFI- CATION.

As the term calcification might be taken in a wrong sense, it should be clearly understood that it is not the same thing as ossification. Calcification is the infiltration of an animal tissue with earthy salts.* Ossification means the formation of true bone—a more highly organized structure. Calcification, in the process before us, is the forerunner of ossification.

Thus much premised, let us examine the process of ossification as observable in the cartilaginous shaft and at the epiphysial ends of what is to be a long bone.

CALCIFICATION OF THE CARTILAGI- NOUS MATRIX.

The process begins by the appearance of an opaque spot in the centre of the miniature shaft. This opacity is occasioned by the enlargement of the cartilage cells, and the calcification of the matrix. These changes spread gradually from the centre up and down the shaft, but stop short of the ends, which are continually growing in advance.

INGROWTHS OF PERIOSTEUM.

At the same time and to the same extent that the preceding changes are taking place in the cartilage, the deep layer of its surrounding perichondrium (future periosteum) sends off vascular shoots (periosteal ingrowths) of connective tissue charged with osteoblasts which penetrate the calci-

* As in the case of shells, or in the cranium of cartilaginous fishes.

fied cartilage and soon make it hollow ; the enlarged cartilage cells disappearing one after another, and their places being taken by the ‘osteoblastic tissue’ from the periosteum.

FIG. 10.

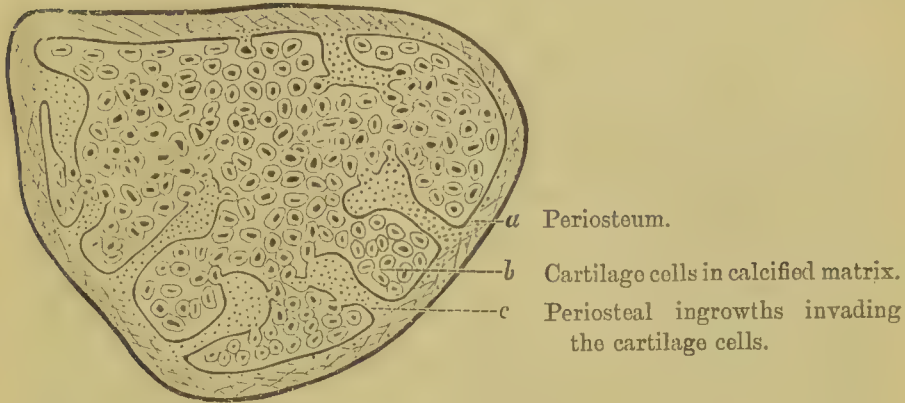


DIAGRAM OF PERIOSTEAL INGROWTHS FROM THE FIRST PHALANX OF GREAT TOE OF A THREE MONTHS' FŒTUS. (TRANSVERSE SECTION.)

FORMATION OF CRUST OF BONE ROUND THE SHAFT. *Pari passu* with this tunnelling of the calcified cartilage by the ingrowths, the deep layer of the periosteum is at work laying down a gradually thickening crust of true bone round the shaft (Diagram, p. 32). This process is not preceded by cartilage, but is direct membranous ossification, as in the tabular bones of the skull.

SUMMING-UP OF RESULTS. To form a correct idea of these separate processes, the mind must grasp them as going on all together, not one after the other. Their general results may be summed up as follows (Diagram, p. 32):—1. The cartilage at the middle is hollowed into a cavity (general medullary) and filled by osteoblastic or bone-building tissue and blood-vessels (*c*). 2. The shaft is surrounded by a circumferential crust of porous bone ; the first rudiment of the true wall (*d*). 3. The cartilage towards the ends is tunnelled (by periosteal ingrowths) into irregular tubular (medullary) spaces, also filled with osteoblastic tissue (*c*). These spaces freely communicate with the general medullary cavity, but are blocked towards the growing ends by a boundary line of cartilage (*b*). It is in these spaces that blood-vessels in injected preparations can be seen running up to the cartilage cells.

4. The walls of these tubular spaces are formed by the slender remains (trabeculae) of the calcified matrix. These slender remains answer a special purpose. They serve as the scaffolding upon which the true bone is laid and by which its cancellous architecture is directed.

FIG. 11.

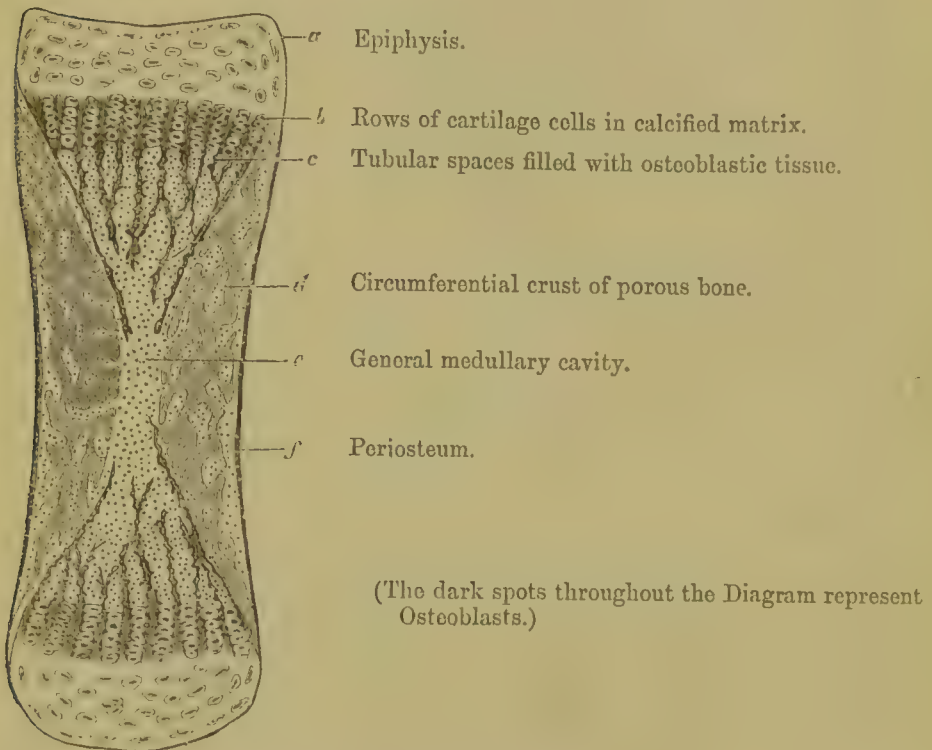


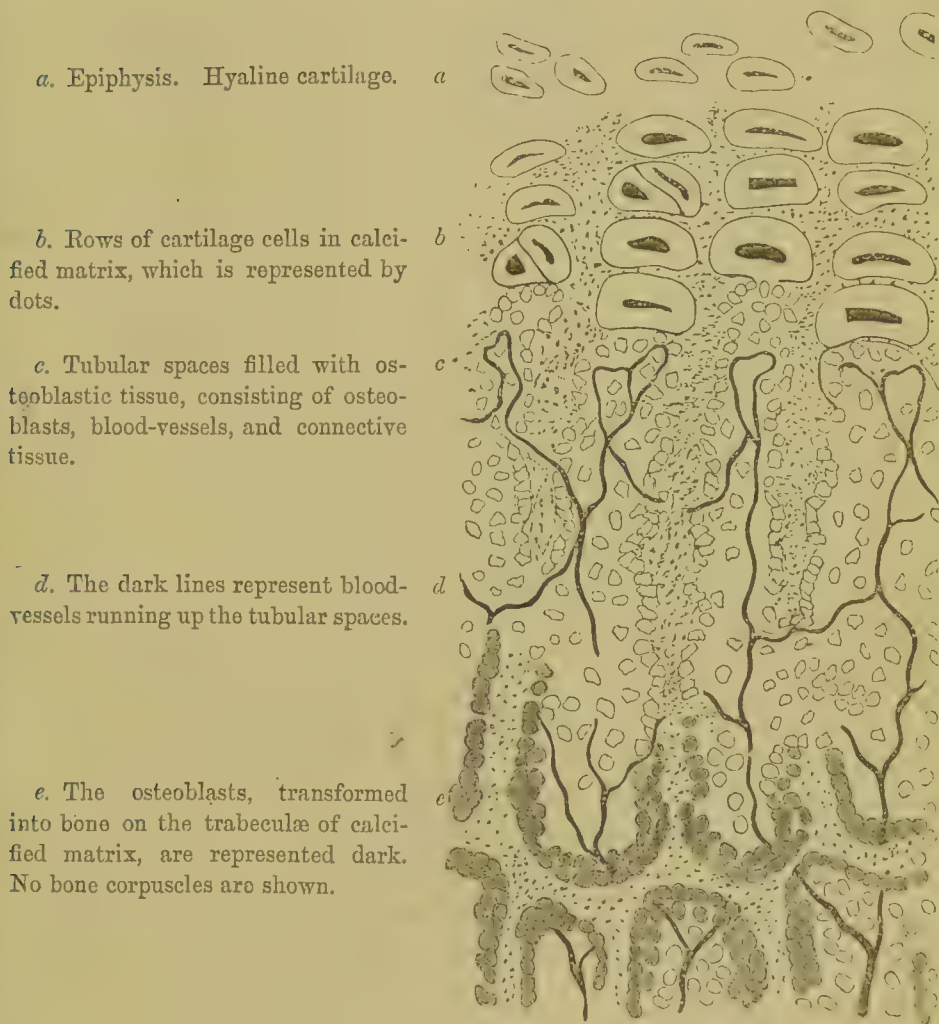
DIAGRAM OF A LONGITUDINAL SECTION OF A FETAL LONG BONE.

For the more minute observation of the process of ossification in cartilage, it is best to take the 'line of ossification' at the epiphysis of a long bone. The enlarged diagram (fig. 12) is intended to illustrate it.

Near the top of the diagram the cartilage cells are seen enlarged and arranged in rows (*b*). The calcified matrix, represented by dots, lies not only between the rows, but between the cells, so that it makes transverse as well as vertical septa between them. A little lower, we see the tubular spaces, filled with the bone-building materials, namely, osteoblastic tissue and blood-vessels (*c*)

and *d*). The blood-vessels form loops along the line of ossification, where the osteoblasts, having absorbed the transverse septa of calcified matrix, are invading the cartilage cells which disappear. We see how the tubular spaces are formed by the vertical

FIG. 12.



EPIPHYSIAL END OF THE SHAFT OF A LONG BONE.

(ENLARGED FROM *a. b. c.* FIG. 11, WITH THE ADDITION OF THE BLOOD-VESSELS.)

remains (trabeculae) of the calcified matrix; how these spaces communicate here and there with each other where osteoblasts have absorbed their walls; how the remains (trabeculae) of the calcified matrix form, as it were, a scaffold upon which the osteo-

blasts are deposited and transformed into bone (*c*). The ossified osteoblasts are represented dark at the bottom of the diagram.

The actual appearances of the process of ossification at the epiphysis, as seen under the microscope, are represented in Plate III., figs. 1 and 2.*

INTERESTING EXPERIMENTS WITH MADDER. That bones grow in thickness by additions to their surface, and not by interstitial deposit, is proved from the interesting experiments made with madder. It was accidentally discovered by Mr. Belchier, that madder tinges the bones a red colour. He gives the following account of the circumstances under which the discovery was made.† He happened to be dining with a calico-printer on a leg of fresh pork, and was surprised to observe that the bones, instead of being white, as usual, were red. On making enquiry, he found that the pig had been fed on the refuse of the dyeing vats, which contained a large quantity of the colouring substance of madder. This fact naturally attracted the attention of physiologists. The red tinge was found to be communicated much more quickly to the bones of growing animals than to those full grown. The bones of a young pigeon were tinged a rose colour in twenty-four hours. In the adult bird it took fifteen days to do it. The effect of madder upon bones depends upon this :—The colouring principle of the madder (*Rubia tinctorum*) has a strong affinity for phosphate of lime. It appears, however, that the vegetable dye does not combine with the phosphate of lime already formed, but only with that which is actually forming and being deposited in the bones. Therefore, since the dye tinges only the most recent deposit of bone, it is possible to produce alternate rings of white and red bone, by periodically administering and withholding the madder as an article of diet. These rings will be observed not only at the circumference of the bone, but also within the Haversian systems.‡

HOW BONES INCREASE IN LENGTH. Bones increase in length, not so much by interstitial deposit, as by addition to their ends :

* For these very accurate drawings, taken from nature, we are indebted to Mr. Shuter and Mr. Schofield, of St. Bartholomew's Hospital.

† 'Philosophical Transactions' for 1736, vol. xxxix.

‡ The preparations of bones coloured with madder in the Hunterian Museum are Nos. 190 to 201. The artificial perforations are Nos. 188, 189, Physiolog. Series.

that is, by progressive ossification of the layers of cartilage which intervene between the ends of the shaft and the epiphyses. These layers of cartilage furnish the animal basis of ossification, by constantly growing on the one surface while they ossify on the other. When the cartilage ceases to grow, ossification still goes on till the component parts of the bone are all united by bony matter; and thus the stature of the individual is determined. If from inflammation or other cause the epiphyses unite sooner than they ought to do, then one limb may be shorter than the other. That bones grow chiefly by addition to their ends was proved by Hunter.* He introduced shots at definite distances into the shaft of a growing bone of a common fowl, and examined them a fortnight or three weeks afterwards. The distance between the two shots was found only half as much increased as the distance between a given shot and the end of the bone.

PRACTICAL RE-
MARKS ON THE
VALUE OF THE
PERIOSTEUM.

Such is an outline of the structure and formation of bone. It is a subject interesting not only for its own sake, but because it helps us towards the explanation of what we are every day seeing of the processes of disease, and the repair of injuries in bone; and what is more, it helps us towards a rational treatment of them. To give a few examples. Look at the value of the periosteum. Suppose a portion of periosteum to be detached by injury or disease from the surface of a bone, a part of the thickness of the subjacent bone will run great risk of dying. It will not *necessarily* die, because its blood-vessels may still be filled from within, owing to the free communication between the blood-vessels of the periosteum and those of the marrow. In a case of compound fracture, where there are loose fragments of bone, we ought not to remove any that are still connected to their periosteum. Or, when a portion of the skull-cap is sliced off with the scalp by a sabre cut, and adheres to it firmly, the scalp and the bone should be re-applied, and the cure will often be effected without difficulty. In the Hunterian Museum are ten skulls which have suffered from severe sabre cuts. The portions of bone thus sliced off were once detached, and afterwards re-united a little out of their proper

* No. 188, Physiological Series, Hunterian Museum.

place, so that the line of separation can be distinctly seen. Again, there are cases in which, either from exposure to cold or from direct injury, acute inflammation of the periosteum of the shaft of a bone ensues, effusion of fluid takes place beneath it, and severs the connection between it and the bone. The death (necrosis) of the entire shaft may be the consequence. Then, what happens? As the inflammation subsides, the bone-secreting layer of the periosteum sets about forming new bone round that which is dead, so as by degrees to enclose it in a bony case. The dead bone lies loose in this new case, having been detached from the articular ends, which (observe) do not die like the shaft; and for this reason,—that they are less compact, and largely supplied with blood by the articular arteries. The articular ends of the old bone become in time the articular ends of the new. Thus, the periosteum has formed a new shaft with a capacious cavity in its interior, in which the old bone is enclosed, and will remain so, and be a source of irritation for years, unless removed by a surgical operation.

Although the periosteum holds the first rank of all the structures which minister to the repair of bone, still we are not to suppose that it is absolutely essential to the process. Where nature finds it necessary that bone should exist, she can form it out of almost any tissue. For example: In a case of compound fracture of the leg, where a portion of the entire circumference of the tibia, including its periosteum, was taken away, the vacancy in the bone was filled up by new osseous substance secreted by the surrounding soft tissues, and there was no shortening of the limb.* Again, we occasionally see the intervening soft tissues forming bridges of bone, to repair a fracture where the broken ends themselves are widely apart.

MATERIAL FOR
THE REPAIR OF
FRACTURES.

In the repair of fractures, nature makes use of material similar to that out of which bone was originally formed. She lays down the animal matter first, which is of a fibrous nature, or cartilaginous,—or perhaps a mixture of both, as the case may be,—and then deposits in it the earthy salts. In the case of a simple fracture, where the

* Stanley, 'Diseases of the Bones,' p. 103.

broken ends are kept in contact and perfectly immovable by artificial splints, the bones unite almost like an incised wound of soft parts. After all the effused blood is absorbed between the broken ends, a soft fibrous substance (blastema) full of osteoblasts is thrown out from the ends of the broken bone, so as to form a thin layer of animal matter (intermediate callus) between them. This gradually hardens, and the bone earth is then deposited in the blastema and cells. Thus the ends are united. It occupies a period varying from four to ten weeks, according to the bone broken; *e.g.* the clavicle and the ribs unite more quickly than other bones, probably from their great vascularity. The process is simply an excess of nutrition. Apparently more new bone than is wanted is formed. The excess fills up the medullary cavity, at the seat of fracture, and rounds off corners and angles if there be any. But when the *permanent* uniting medium is strong enough, nature removes all that is seemingly superfluous, and the medullary canal is restored as it was before, after a period varying from six to twelve months. On the other hand, suppose the fracture cannot be kept steady—for instance, in the case of animals—then nature provides a kind of temporary splint, in the shape of a broad and thick ferule of cartilage, which ossifies round the ends of the broken bone, in order to keep them as immovable as possible, while the permanent process of repair is going on between them. This ferule, termed the provisional callus,* is not removed until the fracture has been thoroughly repaired.

THE VERTEBRAL COLUMN.

(PLATES V. AND VI.)

The vertebral column, or spine (Plate VI.), consists of a series of bones articulated together so as to describe three slight and graceful curves, the bend being forward in the loins, backward in the chest, and again forward in the neck. These bones are called

* 'Callus' is the term applied by the old surgeons to the material by which fractures are repaired.

‘vertebræ,’ because they permit the bending and rotation of the body (*perito*, I turn). They are 24 in number: of which 7* constitute the cervical region, 12 the dorsal, and 5 the lumbar. Below the lumbar vertebræ, the spine is supported upon a bone termed the ‘os sacrum,’ which consists of five vertebræ firmly coalesced into a single bone. Below the sacrum is the little bone termed the ‘coccyx,’ from its resemblance to the beak of a cuckoo (*κόκκυξ*). This also contains the rudiments of four, sometimes only three vertebræ. The vertebral formula of man, therefore, is—7 cervical, 12 dorsal, 5 lumbar, 5 sacral, and 4 coccygeal, or caudal: in all 33.

GENERAL DESCRIPTION OF A VERTEBRA—AND ITS CONSTITUENT PARTS.

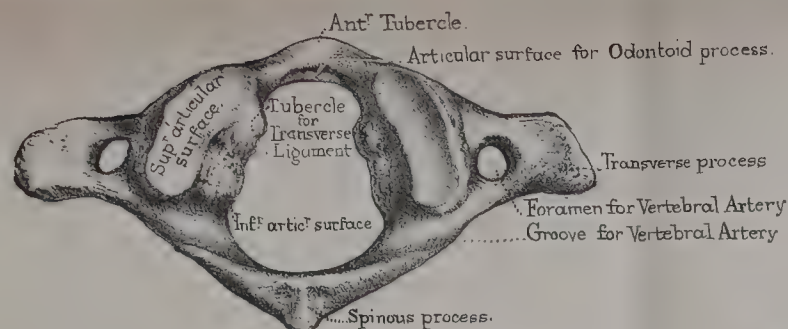
All the vertebræ are constructed upon one plan, and have certain common characters and a general resemblance. These are modified in each region of the spine, to suit its special requirements. Therefore, first obtain a general knowledge of a vertebra, and of the names given to its several parts; afterwards examine the characteristics of the vertebræ in each region.

Taking a lumbar vertebra as a pattern (Plate V.), we find it consists of a ‘body,’ or ‘centrum,’ which forms the columnar part, and supports the weight of the spine. The body is convex in front, but slightly concave behind, in order to assist in the formation of the ‘vertebral foramen,’ for the transmission and protection of the spinal cord. The upper and lower surfaces of the body present a disc of solid bone at the circumference, and are slightly cupped in the centre for the lodgment of the elastic ‘intervertebral fibro-cartilages,’ which in the recent subject intervene, like so many ‘buffers,’ between the vertebræ. These discs or rings of compact bone deserve notice, not only because they strengthen the spongy bodies, but because they have separate centres of ossification, and remain for some time ‘epiphyses’ in early life.† A section through

* In all known mammalia there are seven cervical vertebræ, with the exception of the three-toed sloths (genus *Bradypus*) which have nine, and the manatees and Hoffmann’s sloth (*Choloepus Hoffmanni*) which have only six. In *Bradypus* however the ninth (and sometimes the eighth) bears a pair of short, movable ribs. In the skeleton of the whale, which to outward appearance seems to have no neck, there are as many cervical vertebræ as in the giraffe. See Professor Flower’s ‘Introduction to the Osteology of the Mammalia,’ second edition.

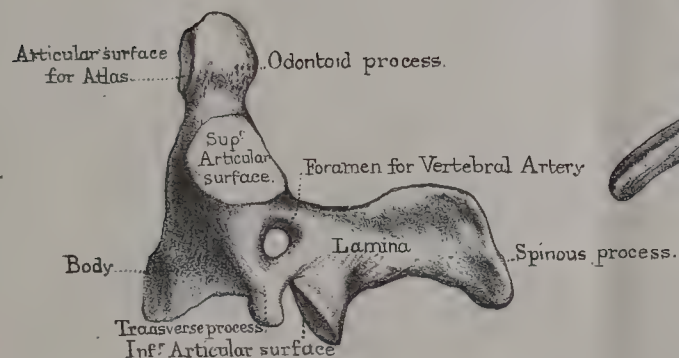
† In the whale tribe (Cetacea) the discs of the vertebræ form complete plates of

Fig. 5.



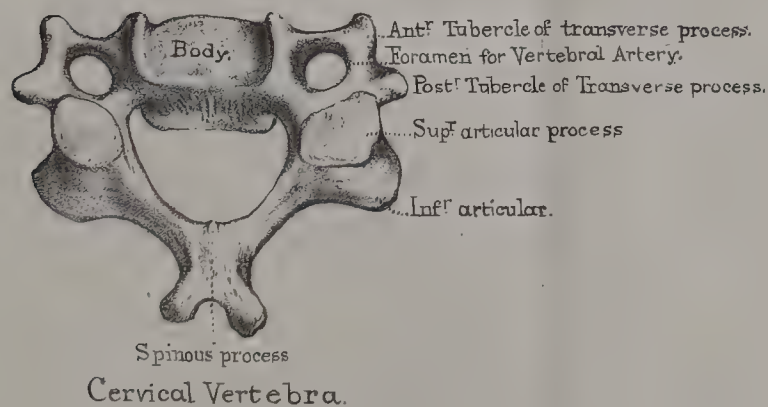
First Cervical Vertebra or Atlas.

Fig. 6.



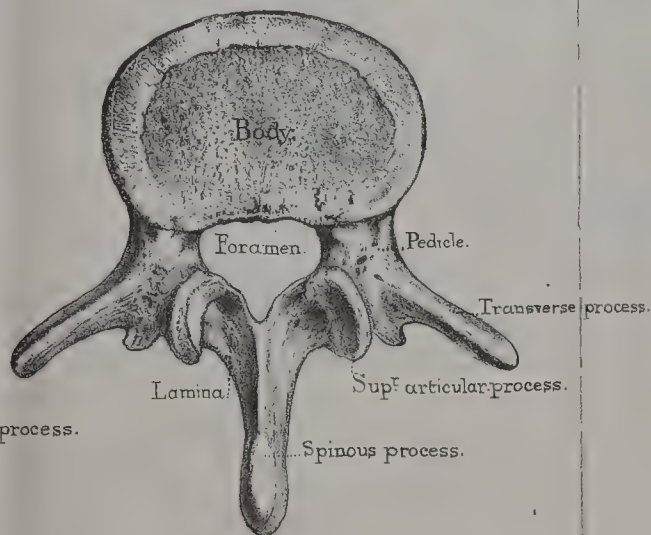
Second Cervical Vertebra or Axis.

Fig. 4.



Cervical Vertebra.

Fig. 2.



Lumbar Vertebra.

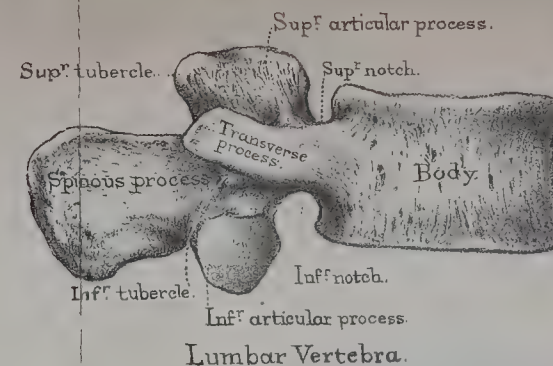


Fig. 1.

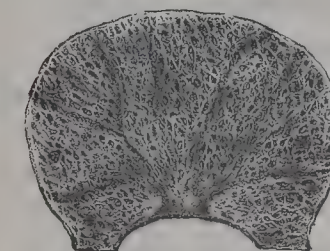


Fig. 7.

Section showing Venous canals.

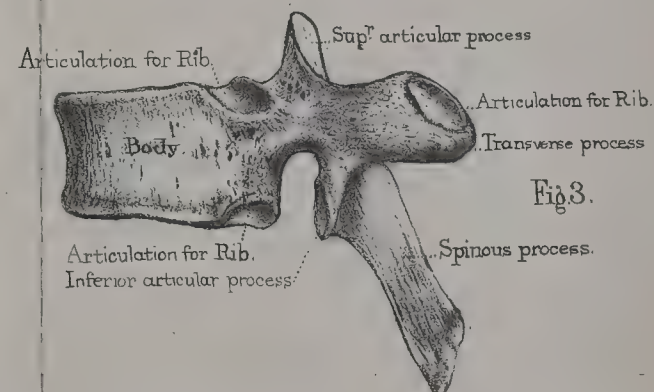


Fig. 3.

Dorsal Vertebra.



the body of a vertebra shows it to be composed of cancellous tissue, which makes it light compared to its bulk. This tissue is traversed by large 'venous canals,' of which the orifices are observable on the surface, but chiefly on the back part of the body, towards which the larger canals converge (Plate V. fig. 7). Behind the body is the 'vertebral foramen.' Now this foramen is formed by two thick processes of bone, which proceed, one from each side of the posterior part of the body, and gradually converging, unite to form an arch (vertebral or neural arch). The spring of the arch, where it joins the body, is called the 'pedicle'; the converging plates are termed the 'laminae.' The arch sends off seven projections, called the 'processes.' Of these, three—namely, the 'spinous' and the two 'transverse'—form levers for the attachment of muscles. The 'spinous process' arises from the top of the arch; the two 'transverse processes' pass off, nearly horizontally, one from each side of it, near the junction of the 'pedicle' with the 'lamina.' The remaining four processes lock the vertebræ together, and are termed 'articular processes'—two superior, and two inferior; they are situated on the point of union of the pedicles with the laminae. Their articular surfaces are covered with cartilage in the fresh state and project beyond the bodies, so that the joints correspond with the intervertebral fibro-cartilages. Lastly, on the pedicles, we observe two 'notches' on either side,—an upper and a lower, the lower being always the larger. When the vertebræ are together, these notches make what are called the 'intervertebral foramina,' for the egress of the spinal nerves. (Plate VII.) The 'pedicle,' or the part of the arch between the notches, is the weakest part of a vertebra, and consequently it is the principal seat of torsion in curvatures of the spine.

Such, then, are the constituent parts of a vertebra: namely, a body, an arch, a vertebral foramen: seven outstanding processes, of which four are for articulation, and three for the attachment of muscles; lastly, the notches for the transmission of the spinal nerves.

great size, and, being separable from the bodies of the vertebræ in many of these animals, are very abundant on the sea-shore in northern climates. Mr. Quekett, in his 'Lectures on Histology,' mentions that when H.M.S. Hecla was wrecked, the crew used these discs as plates.

We must next examine the peculiarities of the different vertebrae; selecting in each case a well-marked example. At the same time it should be especially observed that there is no sudden transition; the peculiarities of one region gradually merging into those of the next.

GENERAL CHARACTERS OF THE LUMBAR VERTEBRÆ.

The general characters of the five lumbar vertebrae are as follows:—The ‘bodies’ are large and oval, with their broad diameters transverse, for the better support of the trunk. The vertical measurement of the bodies is greater in front than behind, in adaptation to the lumbar curve. Their sides are slightly excavated, for economy of weight and bulk. Their ‘spinous processes’ are broad, in their vertical measurement, to give good leverage to the extensor muscles of the spine: they stand out horizontally, so as not to interfere with the extension of the back, and their lower borders are the thickest. Their ‘transverse processes’ are thin and long, and appear like stunted ribs, but are not ribs. Their ‘articular processes’ are vertical, and very strong: the upper, slightly concave, look towards each other; the lower, slightly convex, are nearer together, so as to fit in between the upper ones of the succeeding vertebra. Thus, these articulations are shaped so as to admit not only of extension and flexion of the loins, but also of a certain amount of rotation, which is useful in progression. The ‘vertebral foramen’ is triangular, with the angles rounded.

GENERAL CHARACTERS OF THE DORSAL VERTEBRÆ.

The following are the general characters of the twelve dorsal vertebrae:—Their ‘bodies’ are heart-shaped, and smaller than those of the lumbar, since they have less weight to bear. Their vertical depth is less in front than behind, especially near the middle of the back, in adaptation to the dorsal curve. They have two little cup-like facets on each side for the articulation of the heads of the ribs, the lower cups being the larger. By referring to the spine (Plate VI.), we observe that the socket for the head of the rib is formed by the articular facets of two vertebrae with the intervening fibro-cartilage. Their ‘spinous processes’ are long, clubbed at the end and slant downwards, so that they overlap each other, especially near the middle of the back, and prevent extension of

the spine in this region. Their 'transverse processes' are thick and strong, and have each in front, near their ends, an articular surface for the tubercles of the ribs, which they support like so many buttresses. Observe that the transverse processes of the seven upper dorsal vertebræ are very thick and strong, to support the seven true ribs, whilst the five lower gradually diminish in size; those of the eleventh and twelfth are the smallest of all, since they do not support ribs; these lower ones present three tubercles, of which more will be said hereafter. The 'laminæ' are broad and flat, and slope one over the other. Of the 'articular processes' the upper look backward, the lower forward, and the planes of both are so nearly vertical that it is manifest there can be but little movement between any two dorsal vertebræ. The 'vertebral foramen' is nearly round.

GENERAL CHARACTERS OF THE CERVICAL VERTEBRÆ.

There are seven cervical vertebræ. The first and second are highly modified, and will be described specially. The characters of the five lower are as follows:—Their 'bodies' are broader from side to side than from before backwards, and lateral ridges, one on each side, project from their upper borders, so as to fit into corresponding depressions on the sides of the vertebra above. Moreover, their 'bodies' slope forward, so that the upper overlap the lower a little. By all this interlocking, lateral displacement is prevented; this mechanism compensating for the rather insecure connections of the articular processes. Their 'spinous processes' are horizontal, and some are bifurcated * at the summit for muscular insertion. Those of the sixth and seventh cervical vertebræ are not bifurcated,—they, especially the seventh, project beyond the others: hence the seventh vertebra is called the 'vertebra prominens.' The reason of its greater projection is, to give additional leverage to the elastic ligament (*ligamentum nuchæ*), and the muscles which maintain the head erect. But the spinous processes of the third, fourth, and fifth are especially short, to permit the free extension of the neck, and very distinctly bifurcated; they overlap each other

* This bifurcation of the spines of the cervical vertebræ is almost peculiar to the human skeleton, the object being to afford more room for the insertion of the powerful muscles which maintain the neck, and therefore the head, erect.

a little, as anyone may see in the dry bones by moving them backwards over each other. Their 'transverse processes' are very remarkable. There is a large 'foramen' through their base, for the passage of the vertebral artery: there is a groove on their upper surface for the lodgment of the spinal nerves; and this groove bifurcates their summit, so that it presents two 'tubercles,' an anterior and a posterior, both for the attachment of muscles.* Strictly speaking, we ought to say that the transverse process of a cervical vertebra arises by two roots or bars, an anterior and a posterior, which subsequently join, so as to form a foramen for the vertebral artery vein and plexus of nerves: the anterior root springs from the side of the body: the posterior springs from the arch. Their 'articular processes' are flat, oblique, and inclined, so that their planes make an angle of about 45° with the horizon. The upper processes look backward and upward, the lower forward and downward. Their obliquity permits the requisite flexion and extension of the neck, as well as slight lateral inclination of it. A dislocation of one of these vertebræ may happen without fracture of the articular processes. Such a dislocation is exceedingly rare; but there are specimens † of it in the Museum of St. Bartholomew's Hospital. It may be produced by sudden and forcible rotation of the neck. Baron Boyer ‡ speaks of an advocate who dislocated one of his cervical vertebræ by suddenly turning his head round to see who was coming in at a door behind him.

CHARACTERS OF
THE FIRST AND
SECOND CERVICAL
VERTEBRÆ.

The first and second cervical vertebræ undergo more remarkable modifications than any of the rest, in order to permit the nodding and the rotation of the head.

FIRST CERVICAL
VERTEBRA OR
ATLAS.

The first cervical vertebra (Plate V.) is called the 'atlas,' because it supports the head. This vertebra is like a ring, wider behind than in front, and thickened on each side so as to form 'lateral masses' for the articular surfaces. It has no body, like the others, but only a little 'tubercle' in front, into which is inserted a portion of the 'longus

* Observe especially the large size of the anterior tubercle of the sixth cervical vertebra. It is called the carotid tubercle, being a guide to the carotid artery.

† Ser. iv. No. 8, 12, 13.

‡ 'Traité des Malad. Chir.' t. iv. c. iv.

colli.' The reason generally assigned for this absence is, that the body has been removed to make way for the 'odontoid process' of the second vertebra. But the explanation now generally received among anatomists is, that this same 'odontoid process' is the body of the atlas, and is thus transferred and fixed to the second vertebra in order to form a pivot for the atlas to rotate upon. It seems, at first sight, rather far-fetched to say that the atlas rotates round its own body (detached); but it is nevertheless true, and borne out by the facts of philosophical anatomy. *

Now the entire form of the atlas is modified so as to be adapted to the rotatory movement of the head. In the first place, there is a little articular surface for the odontoid process on the anterior part of the ring of the atlas. The 'spinous process' is reduced to a mere tubercle (the posterior tubercle); for a large spine here would interfere with the free backward movement of the head. The 'rectus capitis posticus minor' is attached to this tubercle. The 'transverse processes' are thick and strong, not bifid, and project far beyond those of the other cervical vertebræ, in order to give greater leverage to the inferior oblique muscles which assist in rotating the head from side to side. Its 'inferior articular' processes are flat, they look downwards and slightly inwards, so as to slide, in the movement of rotation, on the upper articular processes of the second vertebra. The 'superior articular' processes are oval, converging in front, concave from before backwards, and higher on their external brims, so as to form two little cups, looking upwards and inwards, for the support of the 'condyles' of the occipital bone. They not only sustain the whole weight of the head, but are shaped to permit its 'nodding' movement. Within the articular processes we observe two tubercles, one on either side, which gave attachment to the strong 'transverse' ligament, which confines the odontoid process in its position. The 'arch' formed by the laminae is wider than in other vertebræ, to make ample space for the spinal cord.† On the upper surface of each lamina is a groove (sometimes a more

* More will be said on this subject when we speak of the ossification of the vertebræ.

† Hence the possibility of lateral displacement of the atlas without compression of the spinal cord. See a case of this kind, with a drawing, in 'Med.-Chir. Trans.' vol. xxxi., by Sir James Paget.

or less complete bony canal) for the vertebral artery and suboccipital nerve; this corresponds to the superior notch in the other vertebrae. Lastly, the 'notches' for the nerves are placed behind the articular processes, while in all the other vertebrae (except the upper notch in the axis) they are in front of them; and the reason of this is that the articular processes of the atlas must necessarily be advanced well forward in order to meet the condyles of the occipital bone, and to support as well as transmit the weight of the head in the line of the bodies of the succeeding vertebrae.

SECOND CERVICAL VERTEBRA OR AXIS.

The second cervical vertebra or 'vertebra dentata' (Plate V.) is called the 'axis' because it forms the pivot upon which the atlas (with the head) turns. The pivot, termed the 'odontoid process' from its resemblance to a tooth, rises vertically from the 'body' of the axis, and fits into a kind of socket or ring formed in part by the atlas, and completed in the recent state by the strong 'transverse' ligament which passes between the lateral masses of the atlas, and divides the vertebral foramen of that bone into two parts, an anterior for the reception of the odontoid process, and a posterior for the passage of the spinal cord. It is a mechanism, as Paley * observes, resembling a tenon and mortise. The odontoid process has a smooth surface in front, to articulate with the atlas; another behind, for the play of the ligament. There is a distinct synovial membrane and a layer of cartilage on both surfaces, so that they possess all the apparatus of a joint. Moreover, it is slightly constricted at its lower part (forming what is called 'the neck'), that the 'transverse' ligament may clasp it more securely. Lastly, its summit or 'head' is rough, and sloped laterally for the attachment of the 'check' or 'odontoid' ligaments, which fasten it to the occipital bone.† Considering the importance of the odontoid process, we are not surprised that its interior structure is much more compact than that of the body of the axis. The upper 'articular processes'

* 'Natural Theology.'

† Notwithstanding the strength of its ligaments, the odontoid process does sometimes slip out of its ring. The following is an instance:—A lady was carrying her child on her shoulders. Losing its balance, the child clung to its mother's head, and drew it suddenly and forcibly backwards. The lady fell dead. It is more liable to dislocation in children, because the ligaments are weaker than in the adult. Petit relates the case of a child who was instantaneously killed by being lifted by the head.

are placed, partly on the body and partly on the root of each transverse process; they are nearly flat, and slope a little downward and outward. Like those of the first vertebra, they have a very strong base, because they have to transmit to the 'body' the weight of the head. The 'notch' is behind them. The lower 'articular processes' are oblique, and placed considerably behind the upper, so as to correspond with the line of the articular processes of the succeeding vertebræ which they resemble. The intervertebral 'notch' is in front of them, as in all the vertebræ below. The 'transverse processes' are comparatively small, and not grooved or bifurcated; but the hole at their base is inclined obliquely outwards, to suit the curve of the vertebral artery. The 'laminæ' of the arch are remarkably strong. The 'spinous process' stands well out, and bifurcates widely in order to give greater leverage to the inferior oblique muscles which rotate the head. The great size and projection of this *spinous* process is one of the distinguishing characters of the axis; and with this we should associate the large size of the *transverse* processes of the atlas, these being the respective attachments of the inferior oblique muscles.

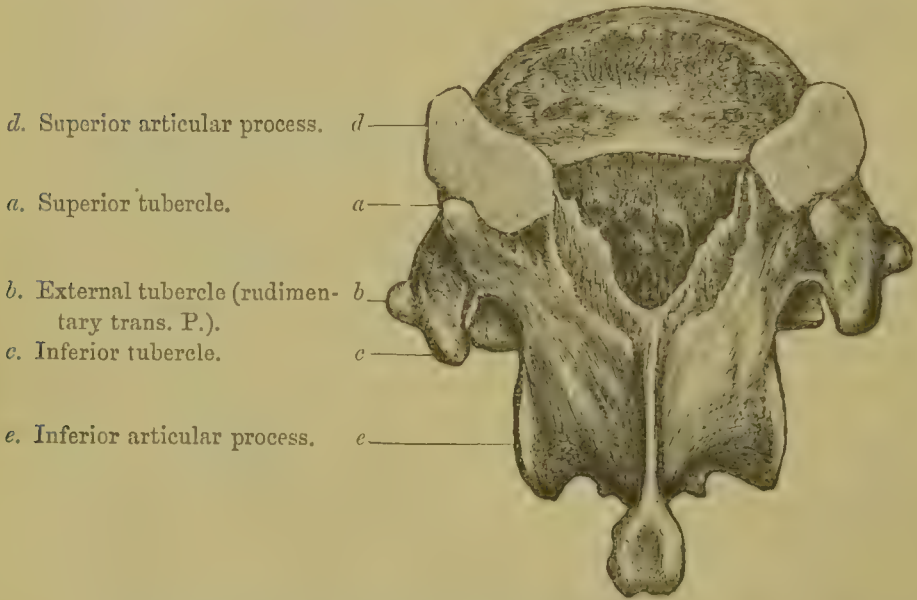
CHARACTERS OF THE SEVENTH CERVICAL VERTEBRA. The seventh cervical is called the 'vertebra prominens,' on account of its long spine, which is not (or very slightly) bifurcated, and resembles that of a dorsal vertebra. This is for the attachment of the elastic ligament (*ligamentum nuchæ*) which assists in keeping the head erect. Its 'transverse process' is long and broad, suggestive of a rudimentary rib.* It is not grooved and bifurcated like the rest, or, if this character be present, it is only slightly marked. The foramen at the base is very rarely absent, though it is never traversed by the vertebral artery.

CHARACTERS OF THE FIRST, NINTH, TENTH, ELEVENTH, AND TWELFTH DORSAL VERTEBRÆ. The 'body' of the FIRST DORSAL vertebra has an entire articular surface for the head of the first rib, and a smaller one for half of that of the second rib. Again, the upper surface of its body has lateral ridges like the cervical vertebræ. The

* The seventh cervical vertebra in some rare instances has two little (cervical) ribs attached to it, one on either side, in form and situation resembling the cervical ribs of animals. A cervical rib may be mistaken for a bony tumour if the surgeon does not

NINTH DORSAL has usually only the upper half facet on the body. The TENTH DORSAL has generally an entire facet for the tenth rib, the lower half facet of the ninth being absent. The ELEVENTH and TWELFTH DORSAL have only single articular facets for the last two ribs. Their 'transverse processes' are much reduced in size, and do not articulate with ribs. Moreover, they are smaller than in the upper dorsal region, and they resolve themselves into three tubercles (seen in the cut, fig. 13). The TWELFTH DORSAL may be

FIG. 13.



TWELFTH DORSAL VERTEBRA, SHOWING THE THREE TUBERCLES ON THE TRANSVERSE PROCESSES.

told from the eleventh by the fact, that its lower articular processes look outward, like the corresponding processes in the lumbar vertebræ. Its spinous process is short and square, and more like those of the lumbar vertebræ. The tubercles of its transverse process are always well marked. (Plate LIII. fig. 2.)

CHARACTERS OF THE LAST LUMBAR VERTEBRA. The last lumbar vertebra is distinguished by the slope on the lower surface of its body, in adaptation to the slope of the sacrum;—by the great thickness of the root of its transverse process which springs

bear in mind that such an anomaly may exist in the skeleton. It is sometimes united with the first rib.

more from the body, this additional massiveness being for the attachment of the ilio-lumbar ligament;—by its lower articulating processes being placed so widely apart, and by its spinous process being somewhat reduced in size, so as not to impede free extension in this part of the back.

TUBERCLES ON
THE LOWER DOR-
SAL AND LUMBAR
VERTEBRÆ.

If you run your eye down the back of a well-marked spinal column, you will find that the transverse processes of the lower dorsal vertebræ have a tendency to become more and more tuberculated at their extremities. This can generally be perceived in the eighth or ninth. In the twelfth (and often in the eleventh) the transverse process has resolved itself into three ‘tubercles’ (see wood-cut). The ‘superior tubercle’ is close behind the superior articular process. The ‘inferior tubercle’ is in a straight line immediately below the superior; the ‘external’ projects in front of the other two tubercles. It will be seen to be in a line with that part of the transverse processes of the upper dorsal vertebræ which bears the ribs. Now, look down lower, and you will find that the ‘superior’ tubercles are very well developed in the lumbar vertebræ, projecting along the whole outer border of the superior articular processes; the ‘inferior’ tubercles, well marked in the two upper lumbar vertebræ, gradually disappear (as a rule) in the three lower. Looking upwards again, you can see that the ‘external’ tubercle of the lower dorsal vertebræ is continued lower down as the thin transverse process of the lumbar region. Hence the transverse process of a human lumbar vertebra is homologous to that part of the transverse process of a typical dorsal vertebra which articulates with the tubercle of a rib. The tubercles are shown in Plate LIII. fig. 2.

In the human subject these ‘tubercles’* serve only for the attachment of muscles; but in some animals, as Professor Owen has pointed out, they attain extraordinary size for particular purposes. For instance: in the armadillo, the superior tubercle is as

* The inferior tubercles are alluded to by Monro, ‘Anatomy of the Human Bones,’ 1726; also by Soemmerring, ‘De Corp. Human. Fabrica,’ 8vo. 1794. The superior as well as the inferior tubercles are developed as little epiphyses with distinct centres of ossification, and unite to the rest of the vertebræ about the twenty-fifth year.

long as the spinous process itself, to help to support the armour. In the *Quadrumanæ* (monkey tribe), the inferior tubercles gain a development in the dorsal and lumbar regions more conspicuous than the articular processes themselves, and contribute to the security of the spine.*

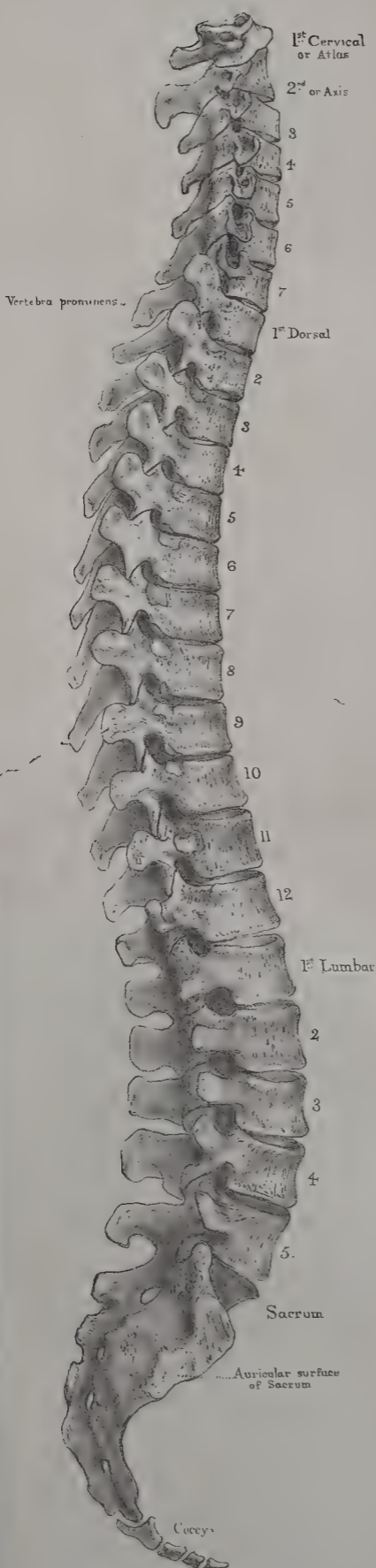
TABLE CONTRASTING THE IMPORTANT PARTS OF THE VERTEBRÆ IN THE DIFFERENT REGIONS.

We have shown how the vertebræ of the different regions of the spinal column may be distinguished, within certain limits, by the examination of any one of their constituent parts. These important parts are contrasted in the annexed table.

BODIES OR CENTRA.	{	<i>Cervical</i> .—Always broadest transversely. Lateral ridges on upper surface.
		<i>Dorsal</i> .—Transverse and antero-posterior measurements nearly equal, except in two or three uppermost. Facets or parts of facets on sides for heads of ribs.
		<i>Lumbar</i> .—Always broadest transversely, somewhat kidney-shaped, no ridges, no facets.
LAMINÆ.	{	<i>Cervical</i> .—Long, thin and flattened.
		<i>Dorsal</i> .—Short, very broad vertically.
		<i>Lumbar</i> .—Very short and stout.
SPINES.	{	<i>Cervical</i> .—Bifurcated, grooved underneath.
		<i>Dorsal</i> .—Long, very oblique, tubercle at summit.
		<i>Lumbar</i> .—Broad and square.
TRANSVERSE PROCESSES.	{	<i>Cervical</i> .—Bifurcated, grooved on upper surface. Foramina for vertebral artery.
		<i>Dorsal</i> .—Large and strong; facets for tubercles of ribs, except eleventh and twelfth.
		<i>Lumbar</i> .—Thin, long and narrow.
SUPERIOR ARTICULAR PROCESSES.	{	<i>Cervical</i> .—Surfaces plane, inclined at angle of 45°, look backward and upward.
		<i>Dorsal</i> .—Surfaces plane, almost vertical, look backward and outward.
		<i>Lumbar</i> .—Surfaces concave, vertical, look backward and inward.

VERTEBRAL COLUMN AS A WHOLE. The spine is a most wonderful piece of mechanism, and has excited the admiration of anatomists in all ages, from the various and apparently incompatible offices

* Of course, in the quadrupeds we have mentioned, our 'superior' and 'inferior' tubercles are 'anterior' and 'posterior.'



which it serves. It forms a column, at once strong and firm, to support the erect position of the body; flexible, to admit the bending of the trunk in various degrees; and elastic, to prevent concussion of the head. It forms a continuous canal at the back of the column for the protection of the spinal cord, a basis for the origin of the muscles which spread over the trunk, and a lever for the muscles which keep the body erect. All these offices are performed by it with so much safety, that even the feats of a mountebank rarely injure the spine.

STRENGTH OF
THE SPINE.

The main strength of the spine depends upon this,—that it consists of a chain of bones so locked together, that the degree of motion between any two is limited, though that diffused through the whole is extensive. Another reason of the strength of the spine is its arrangement in alternate curves. Mathematicians have calculated that it is many times stronger, and more adapted to resist vertical pressure, than if it were straight, the force being decomposed by the curves.* Look at the enormous weight which a man can carry with ease and safety on his head. Moreover, the curves convert the spine into so many elastic springs, to prevent the jarring of the brain. Besides this, the curves are admirably disposed for the lodgment of the internal organs, and the transmission of the weight of the head and trunk in the line of gravity. They are so regular and gentle withal, that the spinal cord runs no risk of compression; and lastly, they give the body that graceful form which has been the ‘line of beauty’ in every age.

The weakest part of the spine is about the last dorsal vertebra: firstly, because it is the narrowest part of the column; secondly, because it is not supported by the ribs like the higher dorsal vertebræ; thirdly, because it is the centre of the spine and the centre of motion in the back, and therefore exposed to the powerful leverage of the spine above and below it. Again, at the articulation between the last dorsal and first lumbar vertebra, the pliable lumbar part of the spine suddenly joins the comparatively rigid dorsal region.

* Rollin and Magendie make it sixteen times stronger; but this must surely be a mistake.

CURVES OF THE SPINE. The curves of the spine are produced partly by the relative thickness of the bodies of the vertebrae in the different regions, but *chiefly* by the relative thickness of the intervertebral fibro-cartilages and the tension and elasticity of the 'ligamenta subflava' which connect the laminae.

EXTENT OF MOTION IN DIFFERENT REGIONS OF SPINE. From common observation, as well as from experiments, it appears that flexion and extension, as well as lateral movement of the spine, are freest in the neck, less free in the loins, and least free in the back. Now the vertebrae are adapted accordingly. Thus, in the *neck* the articular processes are oblique, the spinous processes of the third, fourth, and fifth vertebrae are stunted and horizontal, and the intervertebral substances thick. In the *back* these substances are thin, the articular processes nearly perpendicular, and the spinous processes are long and overlap each other, particularly about the middle of the back from the fourth to the eighth dorsal vertebra; so that there cannot be much movement between the bones. In the *loins*, the thickness of the intervertebral substances, the horizontal and wide-apart spines, and the shape of the articular processes, combine to allow more motion than in the back, but less than in the neck.

The movements of which the spine is capable are threefold: (1) Flexion and extension; (2) Lateral inclination; (3) Torsion. Flexion and extension are freest between the third and sixth cervical vertebrae, owing to their short and horizontal spines; between the eleventh dorsal and second lumbar; and, again, between the last lumbar and the sacrum. This is well seen in cases of tetanus ('opisthotonos'), where the body is supported on the back of the head and the heels; or when a mountebank bends backwards and touches the ground with his head. The lateral movement is freest in the neck and in the loins. The articulations of the lumbar vertebrae admit of a certain amount of rotation or torsion, as proved by the following experiment: Sit upright with your head and shoulders well applied against the back of a chair; the head and neck can be rotated to the extent of 70° . Lean forwards so as to let the lumbar vertebrae come into play; you can then turn your head and neck 30° more.

INTERVERTEBRAL
FIBRO-CARTILAGE.

The intervertebral fibro-cartilage provides for the elasticity as well as the flexibility of the spine. The solidity of this substance gradually diminishes from the circumference towards the centre, where it forms a soft and almost incompressible pulp, permitting, to a limited extent, the motions of a ball-and-socket joint; namely, a gentle bend in every direction, with a small amount of rotation. Its great elasticity breaks the force of jars by gradually yielding, and always tends to restore the column to its erect form. Long-continued pressure during the day will, indeed, make the intervertebral substances yield, so that a man loses in height perhaps $\frac{1}{3}$ or even $\frac{1}{2}$ an inch; but this is recovered after a night's rest. At the same time it should be remembered, that a habit of leaning too much on one side will make the yielding of the intervertebral substance *permanent*. Even the bones themselves, while they are growing, will yield under such circumstances. We may have distortion without actual disease.

SHAPE OF THE
COLUMN FROM THE
FRONT.

As to the form of the column in front, we observe that it is pyramidal, and that the bodies of the vertebræ gradually increase in size from above, in order to form a broad base of support. The atlas, in consequence of the great projection of its transverse processes, necessary for the rotation of the head, tops the pillar like a 'capital.' It is, however, necessary to remark, that there is a partial enlargement of the column about the lower part of the cervical region, to give a broader base to the neck; and again a slight decrease in its breadth, about the third and fourth dorsal vertebræ, to allow more room for the lungs. Moreover, we commonly observe a very gentle lateral curve in the dorsal region, particularly about the third, fourth, and fifth vertebræ, with the concavity towards the left side. The reason of this curve has been much discussed. Some anatomists attribute it to the more frequent use of the right arm; others to the presence of the aorta. The solution of the question is of no practical value; all we need remember is, that the curve is natural. *See Trans. Surg. Society.*

BACK OF THE
COLUMN.

At the back of the column, we observe the long row of spinous processes forming the vertical crest

which gives the name to the 'spine.' At the risk of repetition we will again direct attention: 1. To the suppression of the spine in the atlas, to permit the free extension of the head. 2. To the great projection and bifurcation of the spine of the axis for the attachment of the inferior oblique muscles which rotate the head and atlas. 3. To the shortness and horizontal position of the spines of the third, fourth, and fifth, so as to allow of free extension. 4. To the spine of the 'vertebra prominens' for the attachment of the ligamentum nuchæ. 5. To the overlapping of the long spines of the dorsal vertebræ to limit movement in the region of the heart and lungs, which are not constructed to resist stretching or compression like the abdominal viscera. 5. To the square and horizontal lumbar spines.

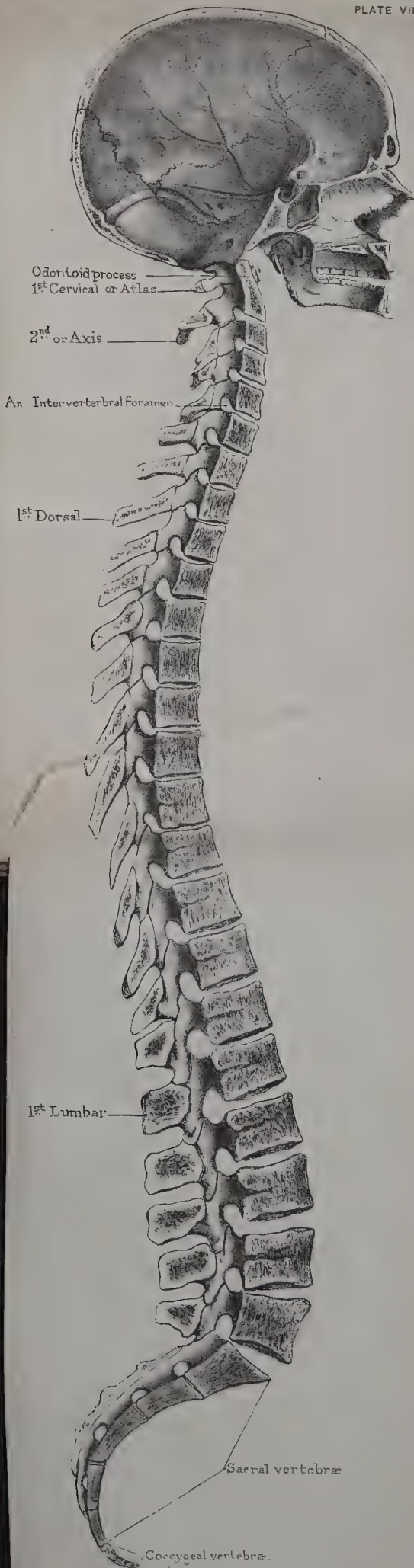
VERTEBRAL GROOVE.

On either side of the spine is a deep furrow, termed the 'vertebral groove,' and formed by the laminae. It is bounded in the neck and back by the transverse processes, in the loins by the articular processes. The groove is narrowest about the junction between the last dorsal and first lumbar vertebræ (the weakest part of the back), and widest at the sacrum. The vertebral groove is occupied by the strong muscles of the back. The crest, being all that we can either see or feel of the spine during life, is the part we immediately examine in cases of injury or disease. In making this examination, we ought to be aware that the spines of the several vertebræ do not always succeed each other in a precisely straight line, but that one, here and there, may deviate to the right or the left, even in persons of the strongest frame.

Observe that in the cervical region the transverse processes are in front of the articular processes, and between the notches; in the dorsal they are posterior to both—so as to make more room for the lungs, and to support the ribs which curve backward; whilst in the lumbar vertebræ the transverse processes are in front of the articular, but behind the intervertebral notches.

VERTEBRAL CANAL.

Respecting the vertebral canal (shown throughout in Plate VII.), remark how well it is protected from injury by the breadth of the arches of the vertebræ. The arches overlap each other, so that it would be difficult for a cutting





instrument to penetrate anywhere, except perhaps in the lumbar region, and, again, between the arch of the atlas and the occiput, where animals are usually 'pithed.' The area of the canal is larger in the lower cervical and in the lumbar region than elsewhere, for two reasons:—first, because the spinal cord itself presents corresponding enlargements in those parts where the great nerves of the limbs proceed from it; secondly, because these regions being the most moveable, the cord runs less risk of compression. Observe well the relative size and mode of formation of the intervertebral foramina by the notches.

OSSEIFICATION OF THE VERTEBRÆ. As a rule, each vertebra is ossified in cartilage from eight centres, of which three are 'principal,'—namely, one for the body and one on each side for the arch and its processes: the remaining five are 'epiphyses,' and appear, soon after the age of puberty, as follows:—one in the cartilaginous end of the spinous process, one in the cartilaginous end of each of the transverse processes, and one for each of the discs which form the articular surfaces of the body.*

Ossification usually commences at the sides of the arch just before it begins in the body of the vertebra,—viz. about the sixth or eighth week after conception. The sides of the arch unite first at the base of the spinous process, so as to complete the ossification of the arch in the first year after birth. During the third year the bases of the arch unite with the independently ossified 'centre' or 'body.'

It must be borne in mind that the sides of the bodies are ossified from the arches; the line of junction is the 'neuro-central suture' of scientific anatomists.

EXCEPTIONS TO THE GENERAL RULE. Where vertebræ undergo great modifications of form, we meet with exceptions to the above rule. Thus the atlas has only two 'primary' centres,—one for each of its lateral halves; and two 'epiphyses,'—one for the anterior tubercle, the other for the posterior. The odontoid process of the axis has two additional centres placed side by side uniting to the body in the third year. It has also two small

* The five epiphyses become united to the vertebra by bone, about the twenty-fifth year.

epiphyses, one at the tip, and another between the centres for the process and the centre for the body of the axis.* These epiphyses are homologues of the discs of ordinary vertebræ, and help to justify the general opinion that the odontoid process is really the body of the atlas; although, if it be so, it is remarkable that this body should have a pair of centres.

There is a separate ossification for the ‘superior tubercles’ or ‘mammillary processes’ of the lumbar vertebræ.

* See Flower’s ‘Introduction to the Osteology of the Mammalia.’

BONES OF THE SKULL.

WE divide the bones of the skull into those which form the ‘cranium’ or brain case, and those which form the skeleton of the face. We shall first describe each of these separately, and afterwards examine the skull as a whole.

8	{	Occipital, Frontal, 2 Parietal, 2 Temporal, Sphenoid, Ethmoid.	14	{	2 Superior Maxillary, 2 Malar, 2 Nasal, 2 Palate, 2 Lachrymal, 2 Inferior Turbinated, Vomer, Inferior Maxillary.
BONES OF THE CRANIUM.			BONES OF THE FACE.		

THE OCCIPITAL BONE.

(PLATE VIII.)

FORAMEN
MAGNUM AND
BASILAR PROCESS.

The occipital bone contributes to form part of the base of the skull, as well as the back of the head. There is a large oval hole in it, called the ‘foramen magnum,’ for the passage of the spinal cord and its membranes, the two vertebral arteries, and the two spinal accessory nerves. The hole is very much larger than the parts which pass through it: all the intervening space is occupied by the watery cerebro-spinal fluid which acts as a protector to the cord. The narrow part of the bone, in front of the hole, projects, with a considerable inclination upwards when the bone is held in its proper position—that is, with the foramen magnum horizontal; it is called the ‘basilar process,’ because it is wedged into the base of the skull. It corresponds with the top of the pharynx. This relation is of

practical importance. It is well to know that the basilar process is within reach of the finger when introduced deeply into the mouth, and that, consequently, we can explore it satisfactorily, so as to ascertain how far a polypus may be connected to it. The end of the basilar process is joined to the body of the sphenoid bone, in early life, by cartilage; but in the adult this cartilage becomes ossified. On its under surface (fig. 1) we notice a tubercle, exactly in the middle line, for the attachment of the aponeurosis of the pharynx; and laterally, rough surfaces for the attachment of the 'rectus capitis anticus major' and 'minor.' On the upper surface (fig. 2) of the basilar process there is a gently sloping groove (basilar groove), which supports the 'medulla oblongata.' The medulla is not in actual contact with the bony groove; a thin layer of fluid is interposed, which, like a water-bed, protects this important part of the nervous system from concussion. On each side of this groove is another, but much smaller (petrosal) groove, for the lodgment of the inferior petrosal sinus.*

The broad arched part behind the foramen magnum contributes to form the skull-cap. On the convex or cutaneous surface, about the middle, we notice a rough prominence, called the 'occipital protuberance,' and from this we trace down to the foramen magnum what is termed the 'crest' of the occiput, which gives attachment to the elastic ligament (ligamentum nuchæ) at the back of the neck. From this middle protuberance and crest we trace outwards, towards the borders of the bone, two lines on either side, termed the 'superior and inferior curved lines.' These lines, as well as the rough surfaces between them, more or less evident in different instances, are traces indicating the attachments of muscles at the back of the neck. The precise attachments of these muscles are mapped out on the right side of the drawing; and in examining them, understand, once and for all, that the blue outline denotes the *insertion* of a muscle; the red, the *origin*.

* The term 'sinus' is used very vaguely in anatomy. It means, generally, the hollow of anything. Thus the air cavities in the bones of the head are termed 'sinuses.' When used in reference to the brain, a 'sinus' means a channel formed by the fibrous membrane (dura mater) of the brain, for the return of its venous blood.

MEANING OF
ORIGIN AND IN-
SERTION.

The *origin* of a muscle is the term generally applied to its most *fixed* attachment; the *insertion* of a muscle is the attachment where the greatest motion is produced. However, it should be understood that a precise rule cannot be laid down with regard to these terms as applied to muscles, since the origin or fixed attachment, and the insertion or moveable one, may under altered conditions be reversed.

Thus, the bone near the superior curved line gives origin to the 'trapezius' and 'occipito-frontalis,' and insertion to the 'sterno-cleido-mastoideus' and 'splenius capitis.' The surface between the two lines gives insertion to the 'complexus.' Below the inferior line are the insertions of the 'rectus capitis posticus major,' the 'rectus capitis posticus minor,' and 'obliquus superior.'

CONDYLES AND
CONDYLOID FORA-
MINA.

The articular processes called the 'condyles' are placed one on either side of the foramen magnum along its anterior half. They are oblong and convex, with their anterior ends converging. Moreover, they slant so that their inner margins are lower than their outer; and thus they are admirably adapted to fit into the 'cups' of the 'atlas' or first cervical vertebra. Owing to this arrangement, and the great strength of the connecting ligaments, dislocation of the head from the atlas is exceedingly rare. More than this, by fitting together the two bones, you find that the condyles of the occiput are much longer than the cups which receive them, in order to permit the backward and forward motion of the head. On the inner side of each condyle is a rough surface or 'tubercle,' for the attachment of the 'odontoid' or 'check ligaments' which limit the rotation of the head. Outside each condyle is the 'anterior condyloid foramen.' The direction of this foramen is outwards and forwards. It gives passage to the 'hypoglossal' or ninth nerve proceeding from the medulla oblongata and distributed to the muscles of the tongue. Immediately above the 'anterior condyloid foramen,' or canal, as it should be called, there is a heaping-up of bone, which, not having received a name, may be termed the 'eminentia inno-minata.' It looks like a strong bony bridge over the canal, and is

obviously for the purpose of strengthening the base of the skull like a flying arch just over the condyle. Behind each condyle is a deep depression or 'fossa,' at the bottom of which we find the 'posterior condyloid foramen.'* The fossa, by making room for the cups of the atlas, enables us to move our heads further backwards than we otherwise could have done; and the foramen at the bottom of it is the opening of a canal which runs horizontally forwards into the 'groove for the lateral sinus' (fig. 2), and transmits a vein from the outside to the inside of the skull.

Immediately external to the condyles, the bone forms on each side a projection, termed the 'jugular eminence.†' On its under surface (fig. 1) there is a roughness for the insertion of the 'rectus capitis lateralis.' On its upper or cerebral surface there is a deep 'groove for the lateral sinus,' one of the large venous canals which return the blood from the brain. Trace this groove forwards, and observe that it turns suddenly downwards, so as to form a kind of gulf (sometimes termed the 'jugular fossa'), which lodges the commencement of the internal jugular vein. Looking at the base of the skull (Plate XXIII.) you will further observe, that it contributes, with the petrous part of the temporal bone, to form the 'foramen lacerum posterius.'

CEREBRAL SUR-
FACE.

On the concave or cerebral surface (fig. 2) we observe two thick ridges of bone, crossing each other,—the one vertical, the other horizontal: both are more or less deeply grooved, for the sinuses of the brain. The groove of the vertical ridge contains the 'superior longitudinal sinus' above, and the 'occipital sinus' below the crossing. Near the foramen

* In some skulls there are no 'posterior condyloid foramina.' In fifty skulls which I have examined I find them more frequently present than absent. Either the right or the left foramen may be absent.

† In very few skulls, there projects from the lower surface of the jugular eminence a more or less prominent tubercle, the '*paroccipital process*.' It is a rudiment of a transverse process. It is quite a deviation from the human type, but is very constantly developed in the mammalian series. There is a good specimen of the process in the Hunterian Museum (No. 5531), in a skull from an aboriginal of one of the Philippine Islands. The process is even longer than the mastoid process, and presents an articular surface for joining the transverse process of the atlas. There is a similar process in a skull in the Museum of St. Bartholomew's Hospital. There are also two specimens of it in the Museum of Anatomy, in Richmond Street, Dublin.

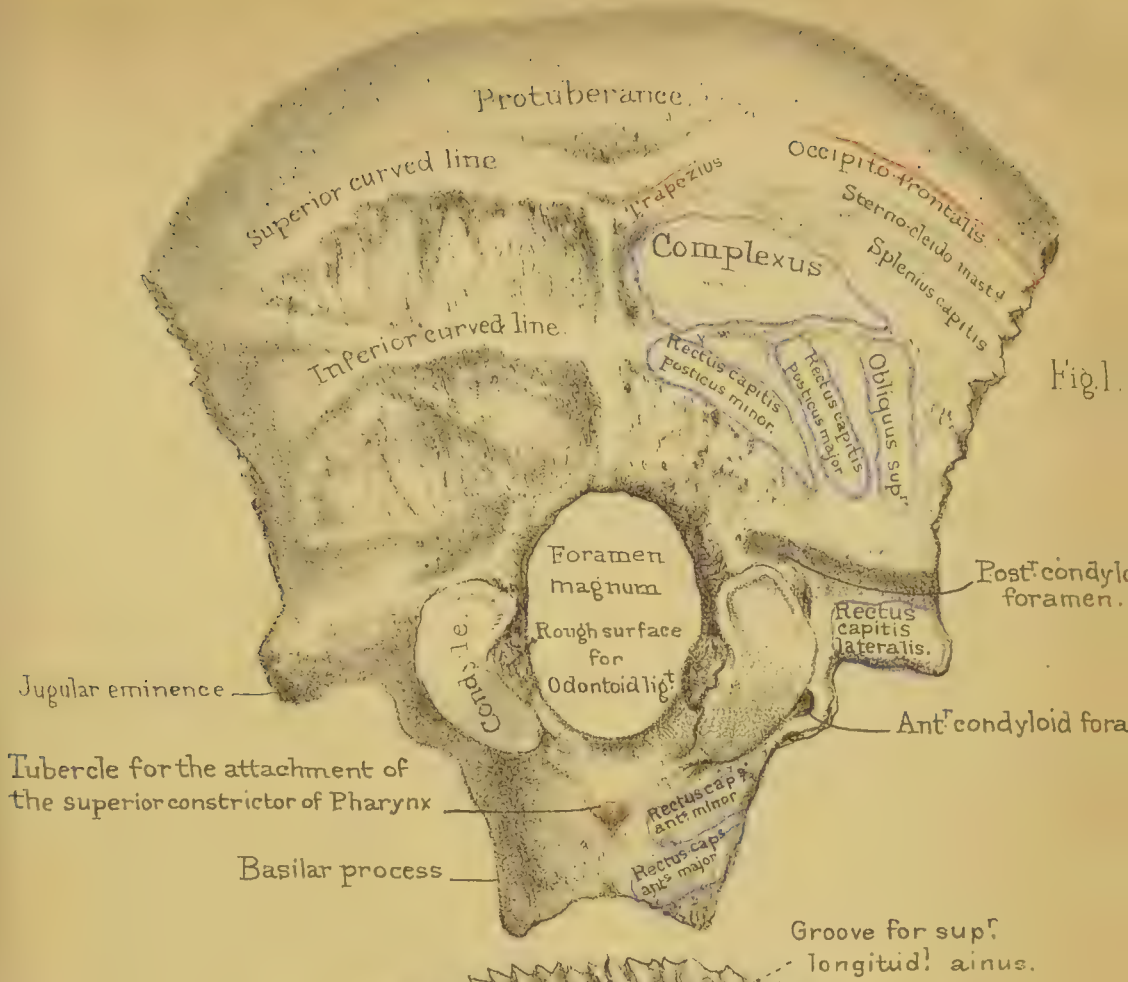


Fig. 1.

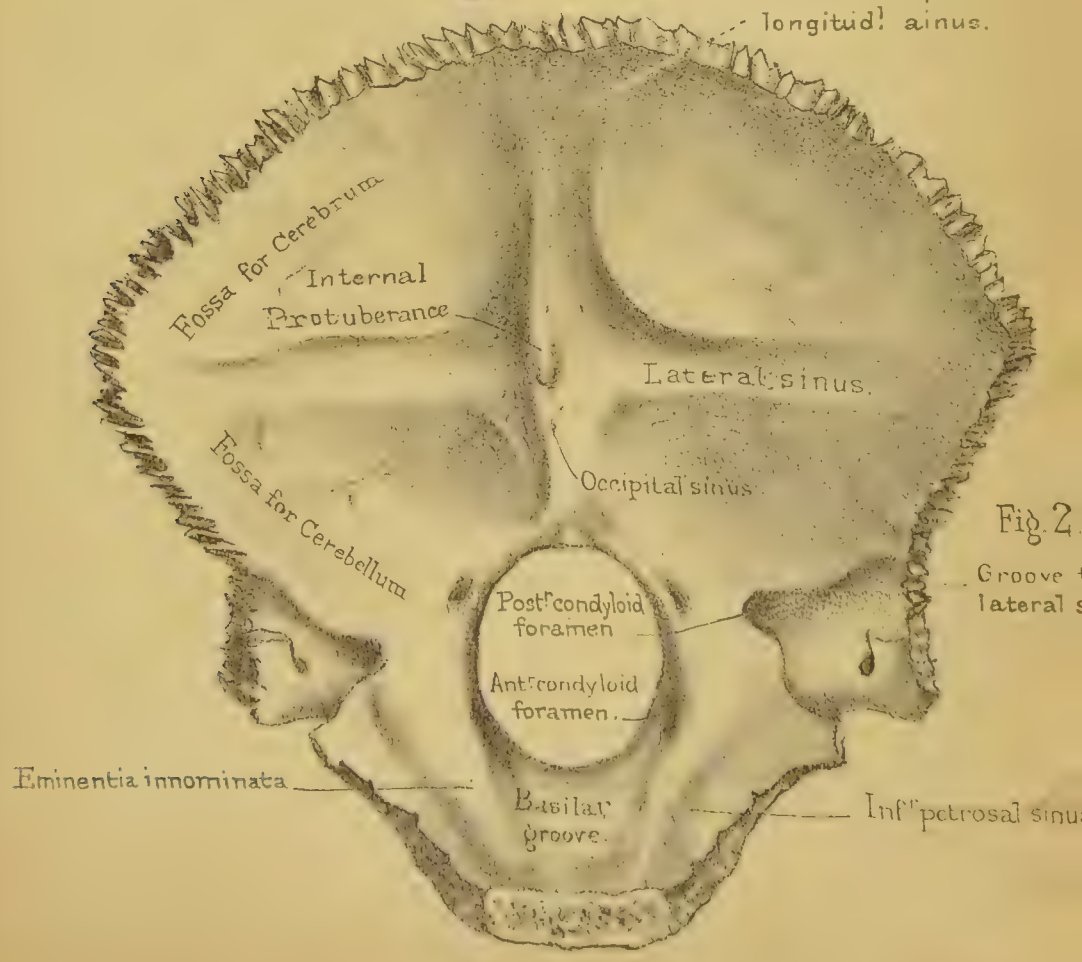


Fig. 2.

Groove for lateral sinus

magnum, the groove for the occipital sinus generally subdivides into two smaller ones, which gradually lose themselves around its margin. The groove of the horizontal ridge contains the great 'lateral sinus.' By referring to Plate XXIII., we may trace this great groove in its winding course along the occipital, part of the parietal and temporal bones, till it is lost at the 'foramen lacerum posterius.' The grooves for the lateral sinuses are seldom equal in size on both sides of the skull: the difference depends upon the relative size of the branches of the superior longitudinal sinus. Generally, the right lateral sinus is larger than the left; hence the larger size of the right internal jugular vein. Besides being grooved for the sinuses, the ridges give attachment to processes of the 'dura mater,' for the support of the lobes of the brain. The horizontal ridge gives attachment to the 'tentorium cerebelli,' the longitudinal ridge to the 'falx cerebri' above, and the 'falx cerebelli' below the crossing.

At the point where the ridges cross each other, there is a heaping-up of bone, termed the 'internal occipital protuberance.' This is by far the strongest part of the bone, and is obviously for the purpose of protecting the back of the cranium; besides which, at this protuberance, no fewer than six sinuses* of the brain meet.

Between the ridges there are four 'fossæ' for the lobes of the brain,—the two upper for the posterior lobes of the cerebrum, the two lower for the lateral lobes of the cerebellum. By holding the bone to the light, you see how thin are the walls of the fossæ for the cerebellum; this being sufficiently protected by the mass of muscles at the back of the neck.

CONNECTIONS. The occipital bone is connected with six other bones; namely, with the two parietals by the remarkably serrated 'lambdoid' suture, with the two temporals, with the sphenoid, and with the atlas; the latter being articulated to the condyles by moveable joints. The sutures are simply named after the bones which they connect: for instance, we speak of the 'occipito-parietal' suture, the 'petro-occipital,' the

* These sinuses are the superior longitudinal, the two lateral, the two occipital, and the straight. The meeting of these sinuses is termed the 'torcular Herophili.' Herophilus fancied that the blood flowing in here would be 'twisted' or 'pressed.'

‘occipito-mastoid,’ and the ‘spheno-occipital.’ All these connections are well serrated, except the ‘spheno-occipital,’ which is quite effaced in the adult skull, and the ‘petro-occipital.’

DEVELOPMENT.

The occipital bone is developed from four distinct centres,—one for the basilar part, one for the occipital, and one for each condyloid part. These segments are, respectively, the ‘basi-occipital,’ the ‘supra-occipital,’ and the two ‘ex-occipital’ foetal elements of the bone. They all meet to form the foramen magnum, and all are distinct at birth.*

P A R I E T A L B O N E .

(PLATE IX.)

This broad and roof-like bone is so named from its forming so much of the wall of the skull-cap. It is the only bone belonging exclusively to the vault of the cranium. With its fellow of the opposite side it makes a beautiful arch for the protection of the brain. It is convex on one surface, concave on the other, and

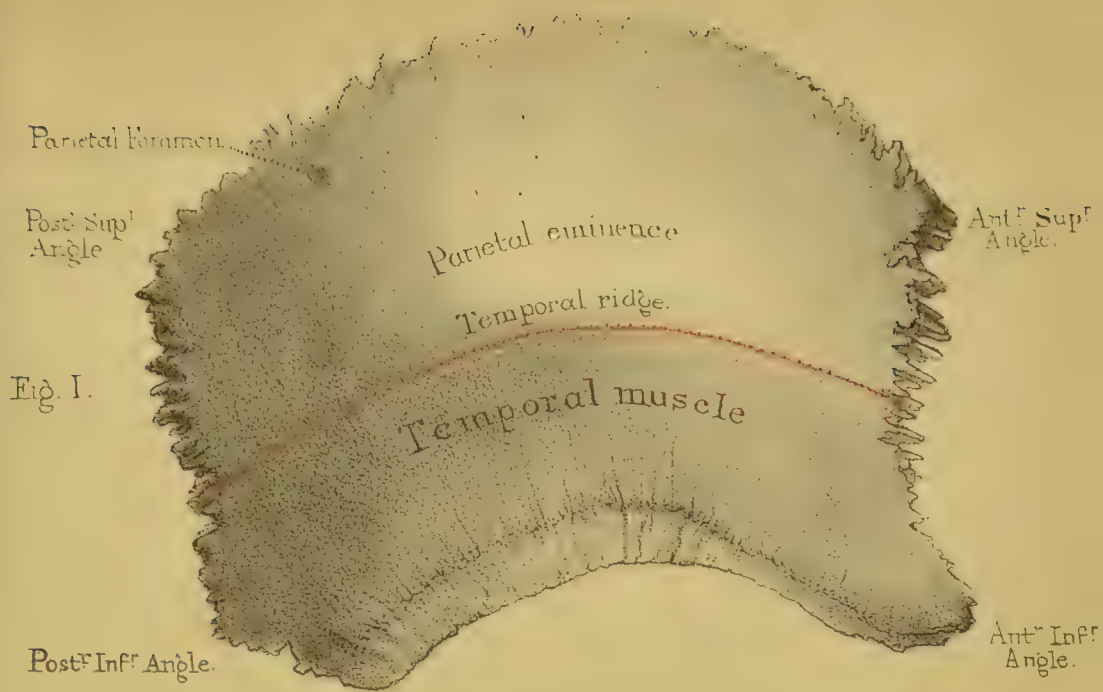
OUTER SURFACE.

somewhat square. On the outer or convex surface (fig. 1), notice the ‘parietal eminence.’ This is the centre from which the bone was developed. Below the eminence is a curved line, termed the ‘temporal ridge,’ which gives attachment to part of the ‘temporal aponeurosis.’ The surface below this line forms part of the ‘temporal fossa,’ which gives origin to the ‘temporal muscle.’ The four angles of the bone are called, respectively, the ‘anterior superior,’ ‘anterior inferior,’ ‘posterior superior,’ and ‘posterior inferior.’

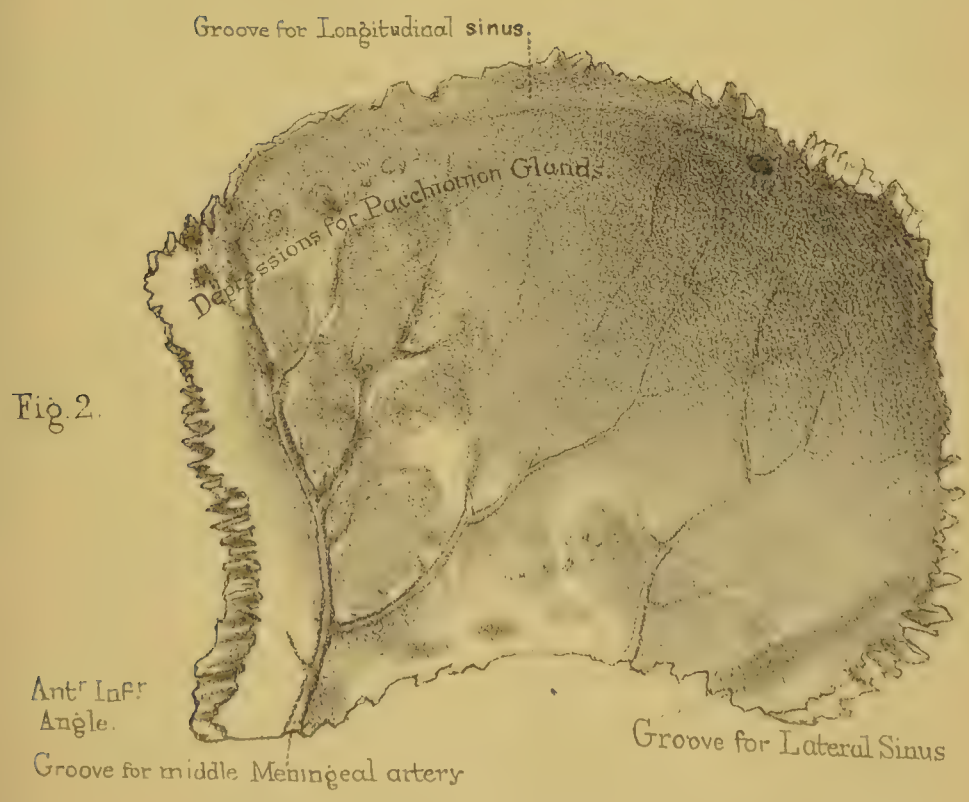
CEREBRAL SUR-
FACE.

Its cerebral surface (fig. 2) is marked by the convolutions of the brain, but chiefly by grooves formed by the ramifications of the ‘middle meningeal artery.’ Observe that the trunk groove (sometimes a complete canal) runs

* The ossific nuclei appear about the seventh or eighth week of foetal life. The occipital and condyloid parts unite about the fourth year. The basilar and condyloid about the fifth.



Parietal Bone



along the anterior inferior angle: hence the greater liability to effusion of blood in this situation; hence the necessity of caution in trephining here. Along the border where the two bones of opposite sides unite—that is, in the middle line of the skull—is the half-groove for the longitudinal sinus, the other half being completed by the opposite bone. Near this border is the ‘parietal foramen’* (fig. 1), which transmits a vein from the outside of the head into the longitudinal sinus. In the skulls of aged persons there are irregular depressions formed by the so-called ‘Pacchionian glands’ near the longitudinal sinus. Lastly, at the posterior inferior angle is a trace of the ‘groove for the lateral sinus.’

CONNECTIONS. The parietal bone is connected by sutures with five bones (Plate XXVII.), as follow:—With the opposite parietal bone, by the interparietal or ‘sagittal’ suture;† with the frontal bone, by the fronto-parietal or ‘coronal’ suture; with the sphenoid bone, by the spheno-parietal suture; with the temporal bone, by the temporo-parietal or ‘squamous’ suture; with the occipital bone, by the occipito-parietal or ‘lambdoid’ suture. We must not fail to notice the beautiful arrangement of the sutures of the parietal bone: the sutural edges are bevelled on alternate sides, so that the bone cannot be driven in without previous fracture. Notice especially the bevelling of the squamous suture. (P. 135.)

DEVELOPMENT. It is developed from one centre, which makes its appearance at the parietal eminence, about the seventh week of foetal life.

FONTANELLES. The term ‘fontanelles’ is given to those membranous intervals in the foetal skull which are seen at the four angles of the parietal bone. These unossified parts are so called from the pulsations of the brain beneath them perceptible in infants, like the bubbling of a spring. They are produced in the following manner. Ossification commences in the centre of the bone, and advances towards the circumference, therefore the

* This hole sometimes transmits a small branch of the temporal artery through the skull-cap to the dura mater. There may be two foramina on one side; or there may not be one.

† In all adult skulls this sagittal suture, though for the most part extremely serrated, is much less so near the parietal foramina. When obliteration of this suture takes place in age, it always begins opposite these holes.

most distant parts of the bone are the last to be ossified. These points are the angles where the several bones eventually meet. There are in all six 'fontanelles' (see Plate XXVII. figs. 4 and 5). Observe the shape of the anterior and posterior 'fontanelles,' and of the two lateral. The *anterior*, situated between the adjacent angles of the parietal bones and the ununited halves of the frontal, is lozenge-shaped, and remains open for some time after birth; indeed, it is not (as a rule) entirely obliterated till the fourth year. The *posterior*, situated between the parietal and the apex of the occipital bone, is triangular and nearly filled up at birth. These 'fontanelles' are of especial importance to the accoucheur, as by the feel of them the finger can detect, during parturition, the position of the head of the child. The *lateral* 'fontanelles' are of less importance, and generally filled up before birth.

FRONTAL BONE.

(PLATE X.)

The situation of the frontal bone is implied by its name. As it forms not only the forehead, but the roof of the orbits, we naturally divide it into a 'frontal plate' and an 'orbital.'

FRONTAL PLATE. The 'frontal plate' is smooth and convex, and gives breadth and height to the forehead. We observe, first, the two 'frontal eminences,' one on each side, familiarly called the 'bumps' of the forehead. They are the two centres from which the bone was originally formed, and their greater or less prominence indicates to a certain extent the amount of brain behind them. Not so the two projections lower down, termed the 'superciliary ridges:' these have nothing to do with the brain, but are occasioned by air-cavities termed the 'frontal cells' or 'sinuses,' situated between the two 'tables' of the skull. And here it may be well to mention, that the cap of the skull consists of two layers of compact bone, called, respectively, the outer and inner 'tables' of the skull, and separated by an intermediate cancellous tissue termed the 'diploe.' We shall allude to the advan-

tage of this structure hereafter (p. 134.); meantime, observe that the frontal cells are formed by the separation of these tables. To see the extent of the cells, one ought to make vertical sections as shown in Plate XX.

POINTS OF INTEREST CONCERNING THE FRONTAL SINUSES.

Let us pause for a moment to consider one or two points of interest about the frontal sinuses.

1. They communicate freely with each nostril through a canal termed the 'infundibulum' (fig. 2); therefore it is possible for insects to reach them.* Blumenbach mentions the case of a lady who had a kind of centipede (*Scolopendra electrica*) for a whole year in one of her frontal cells. It gave her intense pain, and was expelled at last, alive, during a fit of sneezing. It is by no means uncommon to find the larvæ of insects in the frontal cells of animals. Sir C. Bell states that a man, having slept in barns, was afflicted with pains in the forehead, 'which were relieved after he had discharged from his nose a worm belonging to that class which spoils the corn.' 2. As they are lined by a continuation of the same mucous membrane which lines all the other passages of the nose, we have a ready explanation of the aching pain in the forehead in cases of influenza, or a common head cold. 3. In cases of fracture of the base of the skull involving the walls of the cells, it is possible for fragments of the brain to escape from the nose. The author has seen a case of this kind where the patient recovered without any permanent ill effects except partial loss of smell. 4. If the outer wall of the cells be injured by violence or disease, the air, in sneezing or coughing, is liable to escape under the skin of the forehead, and give rise to 'emphysema.'† 5. Their use is, not only to lighten the skull, but to help the resonance of the voice. They are not developed till towards the age of puberty, and progressively increase in size afterwards. In some tribes—for instance, in some Australians—according to Professor Owen, they are never fully developed; and hence arises a certain want of resonance for which their voice is

* 'Histoire de l'Académie des Sciences,' 1708, 1733.

† Hyrtl ('Topog. Anatomio') mentions the case of a boy who was kicked by a horse on the forehead, so that the frontal cells were exposed. There resulted a fistulous opening, through which, when the nose was held, he could blow out a candle.

remarkable.* Lastly, even in Europeans, as common observation proves, their size and extent vary exceedingly. A good idea may be formed of their size in some persons, by the fact that they may lodge a musket ball. Mr. Guthrie† states that a soldier was wounded at the battle of Talavera by a ball which struck him on the forehead and lodged in the frontal sinus. It was readily removed by enlarging the opening, and the man recovered. The author has seen a case precisely similar, in a soldier who was wounded in the Crimea.

The sinuses are commonly separated by a bony partition, often incomplete. These ‘bumps’ are not prominent in children, because the tables of the skull do not begin to separate to any extent before puberty. From an examination of more than 100 skulls, I find that the absence of the external prominence, even in middle age, does not necessarily imply the absence of the sinus itself, since it may be formed by a retrocession of the inner table of the skull. In old persons, as a rule, when the sinuses enlarge, it is by the inner table encroaching on the brain case. The skull wall follows the shrinking brain. The range of the sinuses may extend even more than half way up the forehead,‡ and backwards for an inch or more along the orbital plate of the bone. Sometimes one sinus is larger than the other, and consequently the ‘bump’ on one side of the forehead may naturally be more prominent than that on the other. In the ‘Normal Human Osteology’ series in the Museum of the Royal College of Surgeons, there is an instructive collection of horizontal sections through the frontal bone at the level of the sinuses. In a specimen from a man æt. 32, it may be observed that though the sinuses are very extensive, there is no external protuberance. In another from a man æt. 47 there are no sinuses,

* On this subject see an excellent work by Amman, ‘*De Loquelâ*,’ written in 1700.

† ‘*Commentaries on Surgery*,’ 6th edition, p. 374.

‡ The enormous size of these air-cavities makes the high forehead of the elephant, the owl, &c. In some elephant skulls the tables are as much as twelve inches apart. The head of the old elephant in the Hunterian Museum was riddled with balls before they could hit the brain. The proper place to aim at in this animal is in the hollow just above the root of the nose; here the case of the brain is not much thicker than a shilling.

Fig. 1.

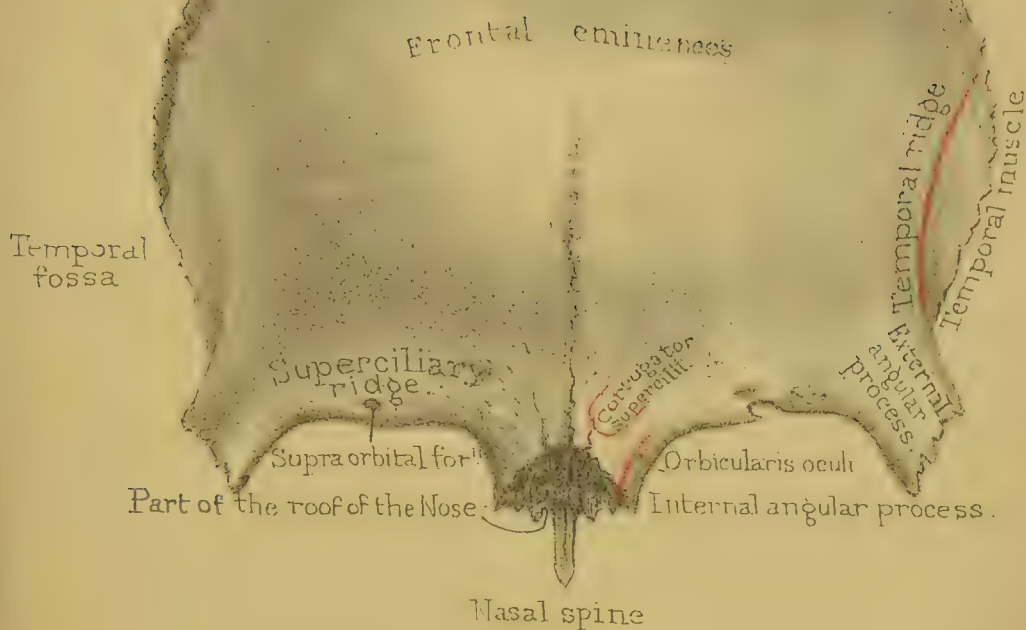
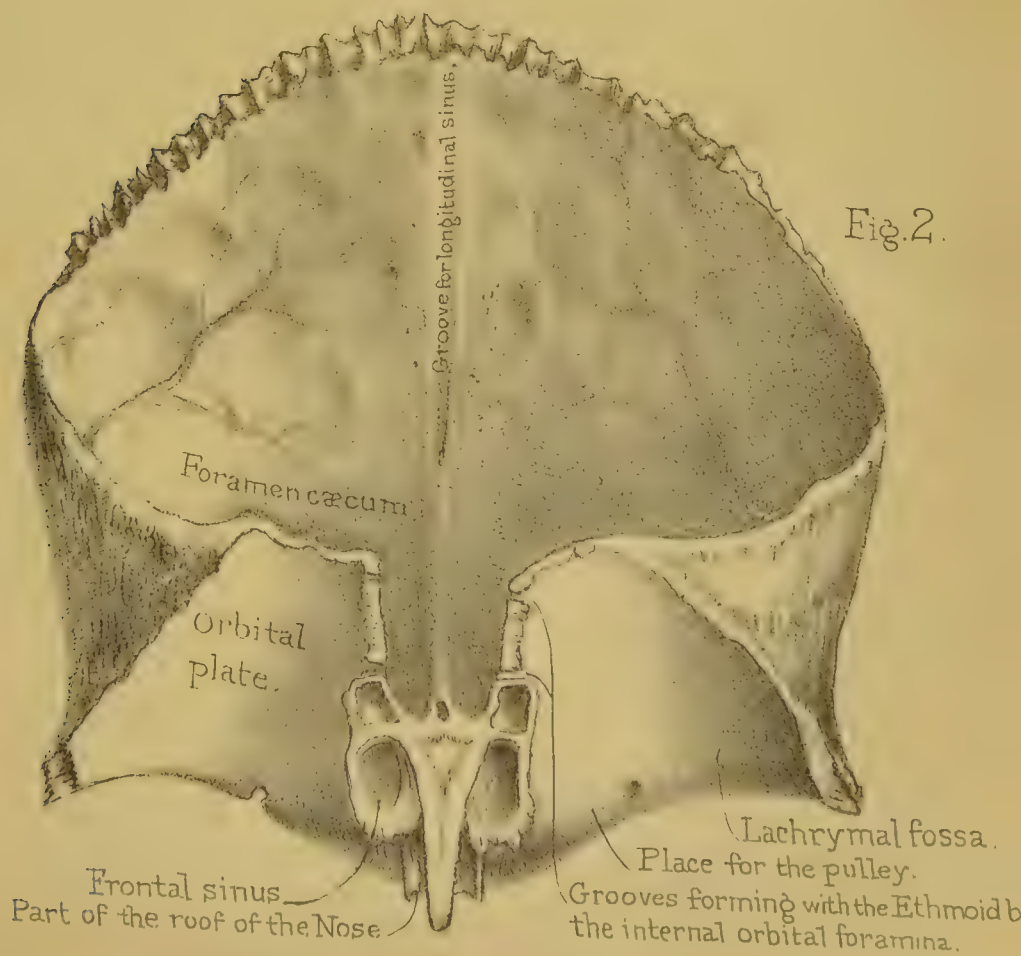


Fig. 2.



yet there is a great external protuberance. One obvious conclusion from all this is, that the ‘bumps’ on the forehead mapped out in this situation by phrenologists, under the heads of ‘Locality,’ ‘Form,’ ‘Time,’ ‘Size,’ etc., do not necessarily coincide with any convolutions of the brain.

ORBITAL MARGIN.

The margin of the orbit, termed the ‘supra-orbital arch,’ is composed of thick and massive bone,—as is, indeed, the entire circumference of the orbit. But the ‘internal and external angular processes’—in other words, the piers of the arch—are remarkably strong, because they form buttresses for its support. Near the inner third of the arch we remark the ‘supra-orbital foramen,’ or it may be a ‘notch’ for the transmission of the supra-orbital nerve and artery. It is this nerve which is affected in ‘brow ague.’ At the external angular process we notice the starting-point of the ‘temporal ridge,’ to which the temporal aponeurosis is attached (Plate XIX. fig. 2); and just below this is a little surface of bone which contributes to form the ‘temporal fossa’ for the origin of the temporal muscle.

CEREBRAL SUR- FACE.

On its cerebral surface (Plate X. fig. 2), we observe that the ‘frontal plate’ is concave, and mapped out by the convolutions of the brain and arterial * grooves. In the middle line is the groove for the commencement of the longitudinal sinus. Tracing the groove downwards, we observe that its margins gradually approximate, and lead to a small hole, the ‘foramen cæcum.’† Though called ‘blind,’ it generally transmits a small vein from the frontal cells into the longitudinal sinus; and this is one of the anatomical reasons assigned why bleeding from the nose relieves congestion of the brain, and why the old practitioners were in the habit of leeching the nose.

Very often the margins of the groove for the longitudinal sinus coalesce, so as to form a small ridge, before they reach the foramen cæcum. They give attachment to a perpendicular fold of the dura

* The anterior meningeal arteries (small vessels given off from the ethmoidal branches of the ophthalmic), and ramifications from the middle meningeal artery, on either side.

† The foramen cæcum sometimes leads into the frontal sinus, sometimes directly into the nose; or it may open on the posterior or anterior surface of the nasal bones. I have seen it transmit a small artery.

mater (termed, from its shape, the 'falx cerebri'), which separates the hemispheres of the brain. In the feline race, e.g. tigers and cats, this partition is bony instead of membranous. Therefore, when we see a frontal bone with a well-marked ridge along the beginning of the longitudinal groove, it is but the extra-ossification of part of a membrane which in some animals is entirely ossified.

ORBITAL PLATES.

The 'orbital plates' (Plate X. fig. 2) extend horizontally backwards, and form a concave roof for the orbit, and a part of the anterior fossa of the cranium. Hold them to the light, and observe how thin they are. In extreme old age, when the diploe of the skull becomes absorbed, the orbital plates have sometimes large holes in them. At any time of life their thinness renders them liable to be perforated by sharp instruments thrust into the orbit. Wounds of the brain from such accidents are sometimes met with. Sir C. Bell speaks of a young man having been killed by the thrust of a foil which had lost its guard, and passed through the orbital plate into the brain. Their 'cerebral surface' is slightly convex, and generally ridged and furrowed by the impressions of the brain.* Their lower surface is concave, more especially near the external angular process, where there is a depression ('lachrymal fossa') for the lodgment of the lachrymal gland. Again, near the internal angular process there is the trace of a slight depression, indicating the attachment of the cartilaginous pulley of the 'superior oblique' muscle of the eye.

ETHMOIDAL NOTCH.

The orbital plates are separated by a wide gap, called the 'ethmoidal notch,' because it receives the cribriform plate of the ethmoid bone, which here fits into the base of the skull. (Plate XXIII.) On each side of the broken margins of the notch we observe incomplete cells with thin walls. These cells correspond with, and are closed by, the ethmoidal cells (Plate XIV. fig. 2). The largest cell of all is in the front; and this, as seen in Plate X. fig. 2, leads into the frontal

* The orbital plates of the frontal bone are more or less arched in different skulls. Of course the more they are arched the more they encroach on the cranial space, and therefore the less room there is for the anterior lobes of the brain. Compare the skull of a monkey with that of a man, and you will observe a marked difference.

sinus. All of them are filled with air, and lined by the mucous membrane of the nose. At the front part of the notch we observe the 'nasal spine' of the frontal bone. This little perpendicular projection—generally broken off in taking the skull to pieces—serves to support the proper nasal bones (Plate XX. fig. 1), and helps to form the septum of the nose, by uniting with the perpendicular plate of the ethmoid bone. On either side of it is a little groove which forms part of the roof of the nose (Plate X. fig. 1). Immediately in front of the nasal spine is the jagged surface which receives the nasal bones, and the nasal process of the superior maxillary bone (Plate XVIII. fig. 2). Lastly, along the broken margin of the ethmoidal notch, notice two canals which, with the ethmoid bone, form the 'anterior and posterior ethmoidal foramina' * for the passage of nerves and arteries from the orbit into the nose.

CONNECTIONS.

The frontal is connected with twelve bones, of which two, the sphenoid and ethmoid, are single. It is united to the two parietal bones by the 'fronto-parietal' or 'coronal suture' (Plate XXVII. fig. 2). Concerning this suture, we must observe how admirably it locks the bones together, and secures the arch of the skull. The margin of the frontal bone is bevelled at the expense of its inner table above, of its outer table below; and the parietal bone is adapted accordingly. The lower half of its temporal margin unites with the greater wing of the sphenoid. Its external angular process is connected to the malar bone; its internal angular process, to the nasal bone and nasal process of the superior maxillary. Its orbital plate is connected to the sphenoid, ethmoid, and lachrymal bones. Look well into the orbits and see these several connections. They form a *continuous suture* from one external angular process to the other. It is called the 'transverse frontal suture.'

DEVELOPMENT.

The frontal bone is developed from two centres, which appear one on each side, in the situation of the frontal eminence. About the seventh week of foetal life, these

* The anterior transmits the 'nasal' branch of the ophthalmic nerve and the anterior ethmoidal artery and vein; the posterior, the posterior ethmoidal artery and vein.

lateral halves unite and form a vertical suture down the middle of the forehead, termed the 'frontal' suture; so that in children the two halves of the bone are easily separated. Generally this suture becomes obliterated during the second year; but sometimes traces of it persist, as seen in the skull, Plate XXVII.; hence the practical rule not to mistake it for a fracture.*

The frontal bone gives attachment to three muscles; namely, to part of the 'temporal,' part of the 'orbicularis oculi,' and the 'corrugator supercilii.'

TEMPORAL BONE.

(PLATE XI.)

DIVISION INTO THREE PORTIONS.

This bone occupies the temples. It is a complicated bone, even on the outside; much more so in its interior, because it contains the organ of hearing. At present we will confine ourselves to the description of all that can be seen on its outer surface. To facilitate this, we divide it into three parts,—a *squamous* portion, situated in the temple; a *mastoid*, forming the little projection behind the ear; and a *petrous*, which contains the organ of hearing, and projects like a wedge into the base of the skull. This division is natural as well as convenient, since each of these parts (the mastoid excepted) is developed from a separate centre of ossification, and remains for some time distinct in childhood. Add to which, they represent permanently distinct bones in some of the lower animals.

SQUAMOUS PORTION.

The squamous portion, named from its scale-like appearance, forms part of the wall of the temple. It is very thin: hence the danger of a blow here. Its outer surface is smooth, and entirely covered by the temporal muscle, to which it gives origin. Its inner surface is marked by

* Dr. Leach and others, who have examined the immense collection of crania in the Catacombs at Paris, have remarked that the number of adult skulls in which the frontal suture remained unobliterated was about one in eleven.

the convolutions of the brain, and by a narrow groove which sweeps, in a curved direction, from before backward, indicating the course of the middle meningeal artery. (Plate XI. fig. 2.)

At the lower part of the squamous portion there is an outgrowth of bone, termed the ‘zygoma’ (ζύγωμα, a bolt or bar). It projects horizontally forwards, and is connected by a strongly serrated suture with a similar projection from the malar bone; so that the two together form an arch (‘zygomatic arch’) beneath which the temporal muscle plays. (Plate XIX. fig. 2.) The base of the zygoma is very broad, and appears to spring from two roots,—an anterior and a posterior: in the space between them is the ‘glenoid cavity,’ which forms the socket for the lower jaw. The *posterior* root (supra-mastoid ridge) runs backwards in the same line with the zygoma, and forms the upper boundary of the glenoid cavity: after that, we trace it over the meatus auditorius externus, and then it gradually fades away, marking the line of separation between the squamous and the mastoid divisions of the bone. In the negro race, this supra-mastoid ridge is strongly marked, and is characteristic of a degraded type of skull. The *anterior* root is the main root of the two: it is very broad and strong, and runs transversely inwards to form the front boundary of the glenoid cavity. It is called the ‘*eminentia articularis*.’ This is crusted with cartilage in the recent state, in order to form additional surface for the play of the lower jaw. Under ordinary circumstances, the ‘condyle,’ or hinge of the jaw, is in the glenoid cavity; but when the mouth is open wide, the condyle slides forward out of the socket, and comes to play on the articular eminence. In fits of laughter or of yawning, when the mouth is opened wide, the condyles may be suddenly dragged by the muscles in front of the articular eminences; and then we have a dislocation of the jaw into the zygomatic fossa. Under such circumstances a person presents a very ridiculous appearance, since the mouth remains wide open until the dislocation is reduced. At the base of the zygoma we notice a little tubercle (‘tubercle of the zygoma’), which serves for the attachment of the external lateral ligament of the lower jaw. Lastly, the upper edge of the zygoma gives attachment to the

temporal aponeurosis; the lower edge gives origin to the masseter muscle.

GLENOID CAVITY. The 'glenoid cavity' (γλήνη, a socket), or socket for the lower jaw, is oval, concave from before backwards, with the long diameter transverse, or nearly so. At the bottom of it notice a fissure, termed the 'fissura (Glaseri),' or 'glenoid fissure,' the remains of the original separation between the squamous and petrous portions of the bone. The part in front of the fissure is the proper socket for the jaw: the part behind it is occupied by a lobe of the parotid salivary gland. Pass a bristle up the fissure, to see that it leads to the tympanum of the ear.* Between the glenoid cavity and the meatus auditorius there is a slight process which affords support to the lower jaw, and guards against dislocation backwards. This 'post-glenoid process' is generally well marked in African skulls, and always so in the gorilla, the animal which makes the nearest approach to man.

MASTOID PORTION. The 'mastoid portion' forms the piece of bone behind the ear, termed the mastoid 'process' (μαστός, a nipple). The chief purpose of this process is to give insertion and greater leverage to some of the muscles† which move the head round. These muscles, as seen in Plate XI. fig. 1, are also inserted into the rough surface above and behind the mastoid process. If a section be made through the process, we find that it is hollowed in the interior by large and freely communicating cells, termed 'mastoid,' which open into the back part of the tympanum. These cells, like the tympanum itself, contain warm air, which is admitted from the back part of the nostrils through 'the Eustachian tube.' They not only make the bone lighter, but are useful to the sense of hearing, by allowing more space for the vibration of the air. Like the frontal cells, and

* The glenoid fissure contains the 'processus gracilis' of the 'malleus,' the tympanic artery; the 'laxator tympani' muscle, and is usually said to transmit the 'chorda tympani' nerve; but this nerve, strictly speaking, runs through a little canal of its own, close by the fissure termed 'Canal of Huguier.'

† The 'sterno-cleido-mastoideus,' under that the 'splenius capitis,' and still deeper the 'trachelo-mastoideus.' Beneath all these muscles the occipital artery runs to the back of the head, along a slight groove (sometimes absent) in the bone.

Fig. 1.

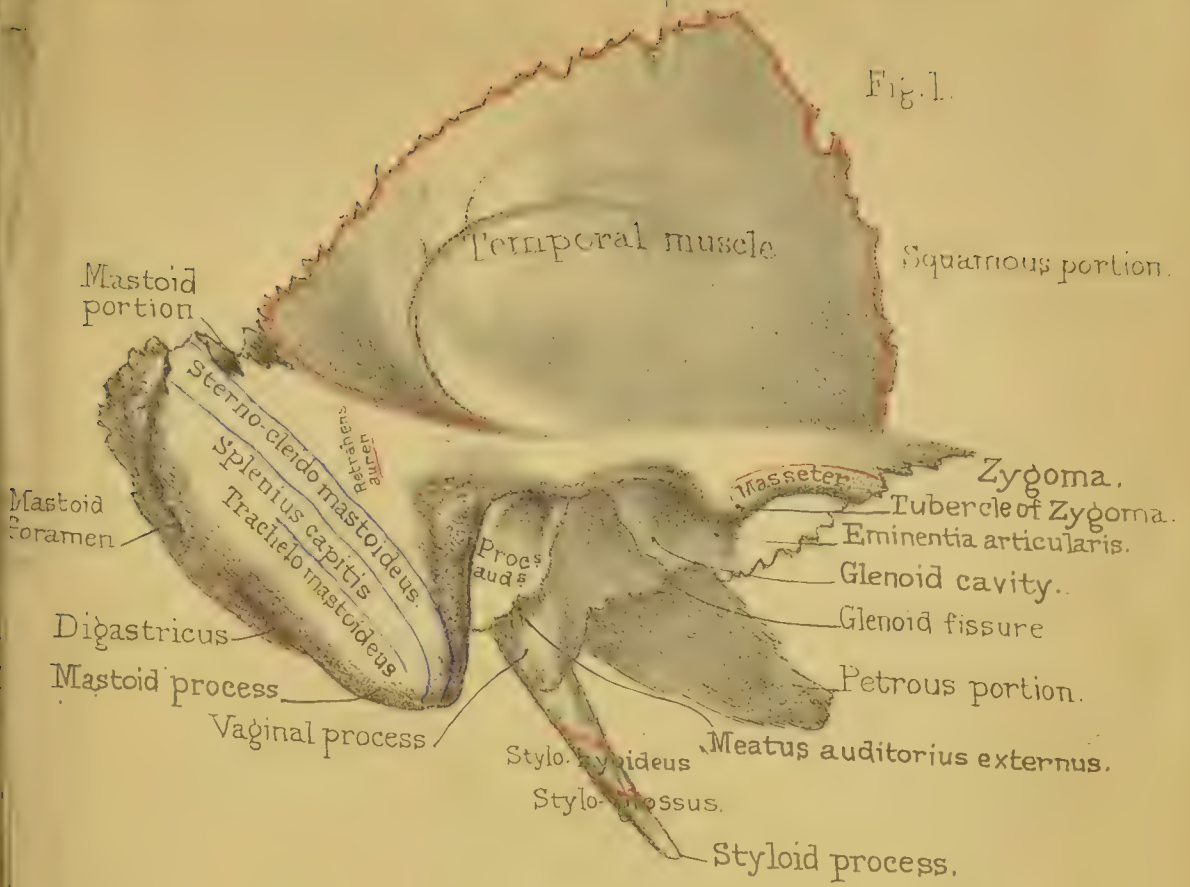
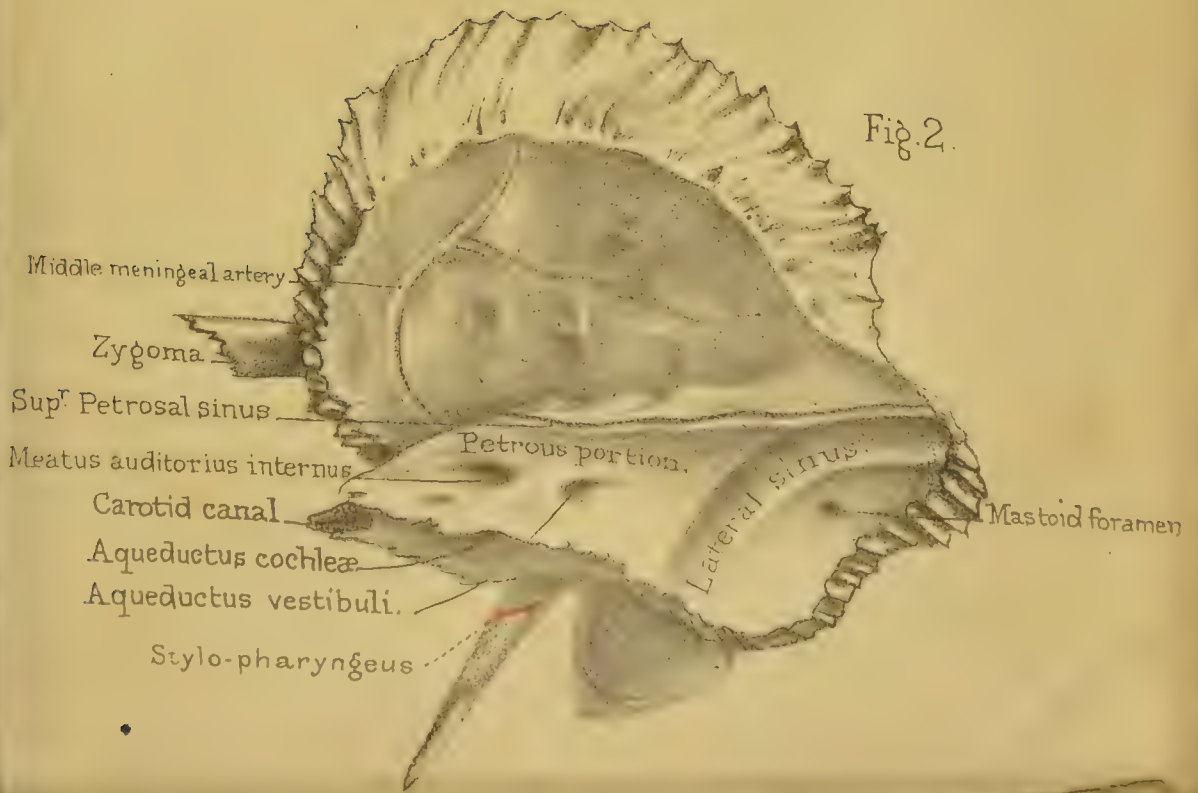
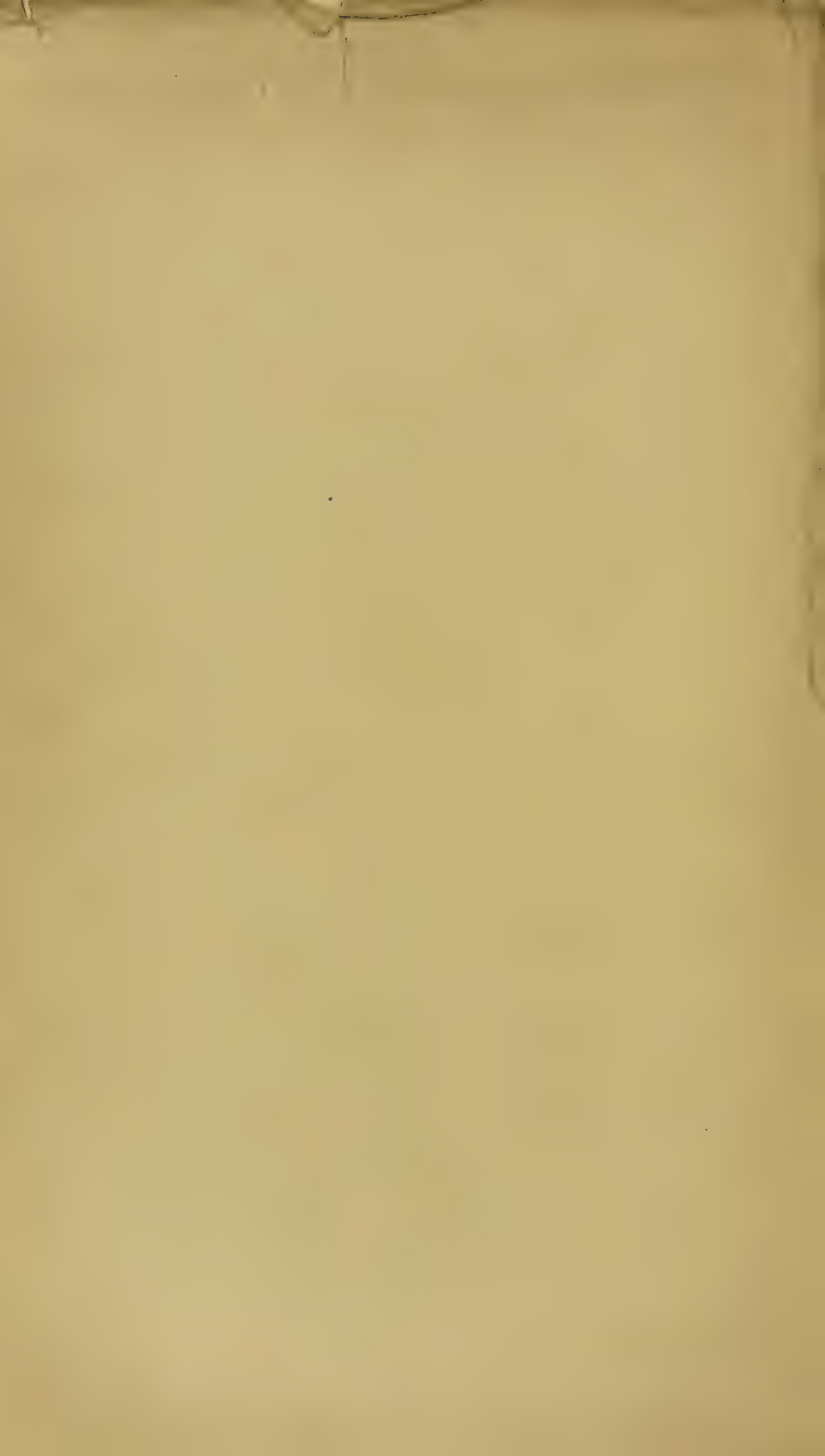


Fig. 2.





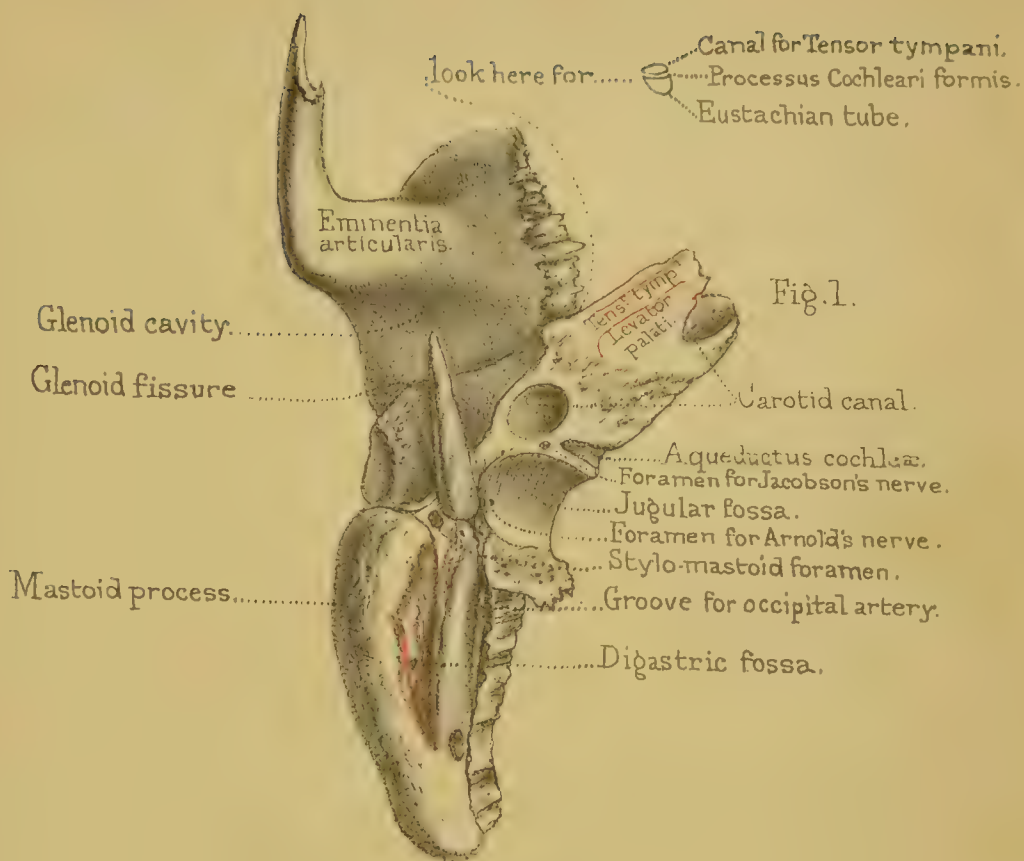


Fig. 1.

TEMPORAL BONE.



Fig. 2.



indeed all the air-cells in the bones of the skull, they are not developed till the approach of puberty. In cases of deafness, arising from obliteration of the Eustachian tube, it was formerly the practice to make an opening into the mastoid cells, in order to admit free access of air into the tympanum. The success attending this proceeding induced Just Berger, physician to the King of Denmark, to have the operation done upon himself; but he died twelve days afterwards from extension of inflammation to the membranes of the brain; and the death of this illustrious man brought the operation into disrepute. Just internal to the mastoid process is a deep fossa, termed the ‘digastric fossa,’ where the ‘digastric’ muscle arises. Behind the process is a hole, called the ‘mastoid foramen,’ through which a vein runs from the outside of the head directly into the lateral sinus. This explains why leeches, applied behind the ears, relieve congestion of the brain. Lastly, on the cerebral aspect of the mastoid portion, we have to notice the ‘groove for the lateral sinus.’

PETROUS PORTION. The ‘petrous portion’ derives its name from the hardness of its constituent bone (*πέτρος*, a rock). It projects horizontally into the base of the skull (Plate XXIII.), so as to carry far out of harm’s way the delicate organ which it contains. Its shape is like a triangular pyramid with the apex inwards; so that, for descriptive purposes, it may conveniently be divided into three surfaces,—an anterior, a posterior, and an inferior: then there is a base and an apex. Our best plan is to examine each of these parts separately, that we may be able to answer the question, what is seen on the anterior, what on the posterior surface, and so forth. Take the base first.

MEATUS AUDITORIUS EXTERNUS. At the *base* of the petrous portion is the orifice of the passage to the ear, termed the ‘meatus auditorius externus.’ It is situated immediately behind the glenoid cavity, and its boundaries are chiefly formed by a curved plate of bone, called the ‘processus auditorius.’ Observe, first, that the edge of it is very jagged, for the attachment of the cartilage of the ear; and then look carefully down the passage to see that the plate we are speaking of forms its boundary wall all round, except at the uppermost part. This inspection will probably

suggest that the whole plate is something superadded to the rest of the bone,—a sort of after-growth; which is precisely the case. In the foetus there is no meatus, but simply a ring of bone,* forming three-fourths of a circle, the deficiency being at the upper part. This ring is ossified independently, about the third month, is quite distinct from the other parts, and is specially intended for the attachment of the drum of the ear (*membrana tympani*); so that at this early period it might be rudely compared to a hoop with a membrane stretched across it. (Plate XXVII. fig. 5.) In process of time, however, the hoop begins to grow out on its external side, and thus transforms itself into the canal or meatus, which, as it becomes longer, gradually coalesces with the other constituents of the bone.

Respecting the shape of the passage, we should observe that it is oval, with the long diameter nearly vertical; therefore all specula used for examining the ear ought to be of the same shape. The narrowest part of the passage, in the recent state, is about the middle; hence if a foreign body, such as a pea, happen to get into the ear, it is generally pushed through the narrow part by clumsy efforts to extract it, and then the moisture of the ear causes it to swell, and makes its extraction most difficult and painful. Mr. Wilde† mentions the case of a boy, eight years of age, into whose ear one of his schoolfellows thrust a grain of Indian corn. The schoolmaster, in his wisdom, endeavoured to remove it by attaching a piece of wax to the end of a stick, and thrusting it into the passage. Four days afterwards, the boy was brought, with his ear in a state of acute inflammation, to Mr. Wilde, who eventually succeeded in extracting the grain by means of a ‘curette,’ with the point bent to a right angle. The grain of corn had increased to one-third more than its natural size.

PETROUS POR-
TION. ANTERIOR
SURFACE.

The *anterior* surface (Plate XII. fig. 2) of the petrous portion forms part of the middle cerebral fossa for the lodgment of the middle lobe of the

* In many animals this remains permanently a distinct bone, under the name of the ‘tympanic bone.’

† ‘Aural Surgery,’ p. 179.

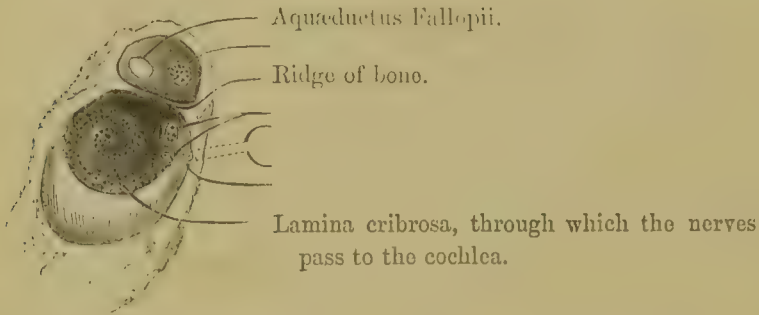
brain, and is more or less marked by its convolutions. About the middle of it is a little eminence, indicating the position of the 'superior semicircular canal' (a part of the internal ear). More forward, is a small furrow leading to an opening termed the 'hiatus Fallopii,' which transmits the 'Vidian' or 'great petrosal' nerve. Immediately to the outer side of this is a smaller furrow and opening, for the passage of the 'lesser petrosal nerve.' Near the apex is a depression for the 'Gasserian ganglion.' External to this is the termination of the 'carotid canal.' Lastly, just at the angle where the squamous and petrous portions meet (Plate XII. fig. 1), you will observe two tubes running backwards parallel to each other, like a double-barrel gun (except that they lie one above the other): they both lead to the tympanum. The upper of the two is the canal for the 'tensor tympani' muscle; the lower, which is by far the larger, is the Eustachian tube, or passage which conducts the air from the pharynx to the tympanum. The thin partition separating the two barrels is called the 'processus cochleariformis.'

PETROUS POR-
TION. POSTERIOR
SURFACE.

The *posterior* surface of the petrous portion forms part of the posterior fossa of the base of the skull. (Plate XXIII.) The most prominent object upon it is the 'meatus auditorius internus' (Plate XI. fig. 2), a large canal which runs nearly horizontally outwards, and transmits the 'seventh pair' of nerves, consisting of the auditory nerve (*portio mollis*), and the motor nerve of the face (*portio dura*). It also transmits the auditory artery, a branch of the basilar. The meatus is much larger than the nerves which it transmits, the space between them and the bony canal being filled by a watery fluid (*cerebro-spinal fluid*), which supports the base of the brain. In fractures through the base of the skull involving the meatus, the fluid sometimes oozes out through the external ear: this, therefore, is regarded as a very dangerous symptom in cases of injuries to the head. If a special section were made to show the bottom of the meatus, we should find that it is divided by a small ridge of bone into two unequal parts, as seen in the cut, fig. 14. In the upper and smaller of the two, there is the commencement of a special canal (*aqueductus Fallopii*) for the motor nerve of the

face; in the lower there are several minute apertures arranged in a spiral form (lamina cribrosa), through which the fibres of the auditory nerve reach the internal ear. About a quarter of an inch

FIG. 14.



behind the meatus is a slit-like opening which looks backwards, and is termed the '*aqueductus vestibuli*.' This, though apparently of considerable size, soon contracts so much that it will barely admit a bristle. It leads to the vestibule of the internal ear. Immediately below the meatus there is a *conical* pit, which is tolerably wide at first, but gradually contracts to a minute canal, leading to the cochlea, termed the '*aqueductus cochleæ*.' The particular use of these minute 'aqueducts' leading to the internal ear is not known: but it is certain they sometimes transmit small blood-vessels.

PETROUS PORTION.
INFERIOR SURFACE.

The *inferior* surface of the petrous portion presents a broken and irregular aspect, and has many holes in it (Plate XII. fig. 1). Beginning near the base, we observe, first, the 'styloid process.*' This long 'process' descends with a slight inclination forwards, and gradually tapers to a sharp point. Its length varies in different skulls; generally it is about one inch long. In old skulls it is sometimes longer: there is a skull in the Museum of St. Bartholomew's Hospital which has a styloid process three inches long. Its use is to give origin to three muscles and two ligaments. The muscles are for the movement of the tongue and pharynx: they

* So called from its resemblance to an ancient 'style,' or pen. It is originally distinct from the rest of the bone, but gradually coalesces with it about the age of three years. In animals it remains a permanently distinct bone.

arise as follows:-- the 'stylo-pharyngeus,' from the inner side of the base; the 'stylo-hyoideus,' from the middle and outer aspect; and the 'stylo-glossus,' from the front of the process (Plate XI. fig. 1). To the tip itself is attached the 'stylo-hyoid ligament,' which runs downward and forward to the os hyoides. In cases where the styloid process is unusually long, it is nothing more than ossification of this ligament. The other ligament attached to the process is the 'stylo-maxillary,' which separates the submaxillary from the parotid gland. Lastly, the fore part of the root of the styloid process is surrounded by a kind of bony sheath, termed the 'vaginal process,' about which there is nothing to be remarked except that it is a continuation of the plate of bone which forms the hinder part of the glenoid cavity.

Between the mastoid and styloid processes is a hole termed the 'stylo-mastoid foramen.' (Plate XII. fig. 1.) It gives exit to the facial nerve (portio dura), which entered the bone at the bottom of the meatus auditorius internus, and lets a small artery * run in to supply the tympanum. If you introduce a stiff bristle into the hole, you will probably succeed in passing it through the bony canal traversed by the nerve from its entrance to its exit. The canal is a complete tube of bone, called the 'aquæductus Fallopii' † after the anatomist who first described it. (Plate LIX.) The passage of this nerve through the temporal bone renders it liable to be injured in fractures of the base of the skull, or in disease of the ear; and this explains why we sometimes have paralysis of one side of the face under these circumstances.

On the inner side of the stylo-mastoid foramen we find a deep depression termed the 'jugular fossa.' This, with a corresponding part of the occipital bone, forms the 'foramen lacerum posterius.' (Plate XXIV.) Here the lateral sinus pours its blood into the commencement of the internal jugular vein, which forms a great bulge to fill the fossa. Here also the eighth pair of nerves leaves the skull (through a little notch in front of the foramen lacerum); and here, one of the posterior meningeal arteries, a branch of the occipital, enters it. On the outer wall of the jugular fossa, near

* The stylo-mastoid, a branch of the posterior auricular.

† Fallopius was a distinguished Italian anatomist, b. 1523, d. 1563.

the root of the styloid process, we find the minute foramen for 'Arnold's nerve.' In front of the jugular fossa is the large circular commencement of the canal in the petrous bone, through which the carotid artery enters the skull ('carotid canal'). Observe that the canal mounts nearly perpendicularly for a short distance, and then, turning horizontally forward and upward, emerges at the apex of the bone. On the plate of bone which separates the jugular fossa from the carotid canal, there is a minute foramen for 'Jacobson's nerve.'* Near the apex is a rough surface which gives origin to the 'tensor tympani' and 'levator palati' muscles. The apex itself presents nothing more than the termination of the carotid canal, and helps to form one of the boundaries of the ragged hole at the base of the skull, termed the 'foramen lacerum medium.' (Plate XXIV.)

Along the sharp border between the anterior and posterior surfaces of the petrous portion we remark the groove for the 'superior petrosal sinus,' which discharges itself into the lateral sinus. The faintly indicated groove along the fore part of the lower border of the posterior surface is for the 'inferior petrosal sinus.' The neighbourhood of these venous channels to the cavity of the tympanum explains why bleeding from the ear sometimes occurs in fractures running through the petrous portion of the temporal bone.

THE TEMPORAL BONE. The temporal is connected with five bones. The squamous portion is connected to the parietal bone and the great wing of the sphenoid bone by the 'temporo-parietal' and 'temporo-sphenoid sutures,' concerning which the following mechanism must be noticed; namely, that the squamous part overlaps the parietal above, but is itself overlapped by the sphenoid below,—an arrangement which greatly contributes to the security of the arch of the skull. The mastoid part is connected, above, to the inferior angle of the parietal by the 'masto-parietal' suture, and, behind, to the occipital by the 'masto-occipital' suture. The petrous part is wedged into the base of the skull between the sphenoid and occipital bones. (Plate XXIII.) The zygomatic process is connected to the malar bone

* Arnold's nerve is a branch of the pneumo-gastric; Jacobson's nerve is the tympanic branch of the glosso-pharyngeal.

by a strong suture, the 'zygomatic,' the lower part of which slopes much backwards. Lastly, the glenoid cavity articulates with one of the condyles of the lower jaw. In the living subject, an inter-articular fibro-cartilage, lined above and below by a synovial membrane, separates the two articular surfaces, and one of its purposes is to protect this part of the skull from the effects of a blow under the lower jaw.

DEVELOPMENT
OF THE TEMPORAL
BONE.

The temporal bone is developed from four centres of ossification; namely, one for each of the following parts:—the squamous, including the zygoma; the petrous, including the mastoid process; the tympanic or processus auditorius; and lastly, the styloid process. These remain permanently distinct bones in the lower animals; and it is worthy of remark, that even in the human subject traces of the union of all are visible even in advanced age. The most curious development is that of the tympanic part, which, a simple ring of bone in the foetus, channelled inside for the attachment of the membrana tympani, eventually grows out so as to form the meatus auditorius. In the foetus, the mastoid part is very small, and gradually enlarges towards puberty by the formation of the mastoid cells. The styloid part is for a long time cartilaginous after birth, and ossifies slowly with age.*

SPHENOID BONE.

(PLATES XIII., XIV.)

CONSTITUENT
PARTS.

The sphenoid bone is so called because it is wedged in at the base of the skull between all the other bones of the cranium ($\sigma\phi\eta\nu$, a wedge, $\epsilon\acute{\iota}\delta\omicron\varsigma$, form). As it not only enters into the formation of the base of the skull, the orbits, the temples, and the nasal passages, but is also connected with all the bones of the cranium, and many of those of the face, one

* The ossification of the squamous part commences about the eighth week of fetal life; of the petrous and mastoid, between the fifth and sixth months; of the tympanic ring, about the third month; of the styloid process, after puberty.

cannot be surprised that it is a difficult bone to understand. Fortunately, it bears a remarkable resemblance to a bat with extended wings; so that we can shape our description accordingly. It presents, then—1. A body, or central part; 2. The two greater wings; 3. The two lesser wings; 4. The pterygoid processes, which make the two legs of the bat.

BODY AND ITS FOUR SURFACES. Commencing with the body, we must examine its four surfaces—a ‘superior,’ an ‘inferior,’ an ‘anterior,’ and a ‘posterior.’

The *superior* surface of the body (Plate XIII. fig. 1) comprises what is seen of the body on the inside of the base of the skull. There is a deep depression in it, termed the ‘pituitary fossa,’ for the lodgment of a gland belonging to the brain (the ‘pituitary’ body).* Another name given to it is the ‘sella turcica,’ from its resemblance to a Turkish saddle. In front of it is an eminence, termed the ‘olivary process,’ from its olive-like shape. There is nothing remarkable in this process except that it supports the commissure of the optic nerves, which make a slight transverse groove (the ‘optic groove’) upon it, leading on each side to the ‘optic foramina’ through which they enter the orbit. In front of the olivary process is a smooth and slightly excavated surface, which supports the olfactory nerves, and terminates in the middle line in the ‘ethmoidal spine,’ which articulates with the ethmoid bone.

Each side of the ‘body’ is more or less distinctly marked by a broad groove which winds upwards in a gentle curve, and lodges the internal carotid artery as it passes through the ‘cavernous sinus’ after entering the skull.† The pituitary fossa is bounded behind by a square plate of bone, which, as it represents the back of the saddle, is termed the ‘dorsum sellæ.’ The corners of this

* This name was given to it by Galen, who thought that it secreted the ‘pituita,’ or mucus, and that this passed down into the throat through the small foramina which are often found at the bottom of the fossa (De usu partium, lib. ix. cap. 1). Its functions are not even yet understood; it is generally classed as a ‘ductless’ or ‘vascular gland,’ along with the spleen and thyroid body.

† Generally, a little tubercle, called the ‘middle clinoid process,’ rises from the side of the groove to keep the artery in its place. In some skulls this tubercle is long enough to unite with the apex of the anterior clinoid process, so that the artery, in emerging from the groove, passes through a ring of bone. The two ‘clinoid’ processes on each side give attachment to the ‘tentorium cerebelli.’

plate project so as to form what are called the ‘posterior clinoid processes,’—thus named from their resemblance to bed-posts. These are directly opposite to the ‘anterior clinoid processes,’ of which we shall speak presently. The posterior surface of the plate slopes very obliquely backwards, is continuous with the basilar process of the occipital bone, and forms an inclined plane for the support of the ‘pons Varolii.’ Lastly, the sides of the plate are generally notched for the passage of the sixth pair of nerves.

The *posterior* surface of the body is immovably connected with the basilar process of the occipital bone, in young subjects by cartilage, in adults by bone, so that after a certain age it is impossible to separate the ‘basilar suture’ without the saw. The section shows well the structure of this part of the base of the skull; namely, two plates of compact bone separated by about $\frac{3}{10}$ of an inch of cancellous tissue or ‘diploe.’ Thus the bone is rendered lighter, and shocks transmitted to the base of the skull are broken. (Plate VII.)

The *anterior* surface of the body (Plate XIII. fig. 2) is adapted to fit the posterior part of the ethmoid bone. It presents in the middle line a perpendicular plate of bone termed the ‘rostrum.’ This forms part of the bony septum of the nose, and is connected in front with the perpendicular plate of the ethmoid bone, and below with the vomer; as may be seen in Plate XX. fig. 1. The surface of bone on each side of the rostrum is com-

CORNUA SPHENOIDALIA. pleted by two plates of bone, one on each side, termed the ‘*cornua sphenoidalia*’ or ‘sphenoidal turbinated bones.’ Although apparently integral parts of the sphenoid, yet these little bones are formed each from a special centre of ossification, are distinct in early life, and remain separable till adult age. The annexed woodcut (fig. 15) shows the ‘*cornua sphenoidalia*’ removed in a perfect state. The rostrum of the sphenoid would fit into the gap between them. Each cornu is triangular with the apex downwards. Each completely walls in the sphenoidal cell of its own side, except at the upper part, where there is a round opening in the base of the cornu for the admission of air from the upper meatus of the

FIG. 15.



CORNUA SPHENOIDALIA.

nose. Fig. 16 represents one of the cornua seen from the surface towards the sphenoidal cell. It shows the thin scales of bone which project into the cell and assist in lining its walls. However, it is right to state that these cornua sphenoidalia are rarely met with perfect. In consequence of their coalescence with the sphenoid, ethmoid, and palate bones, they are generally broken in separating the bones, so that there appears in most sphenoid bones a large irregular hole leading into the cell; as shown on one side of Plate XIII. fig. 2.



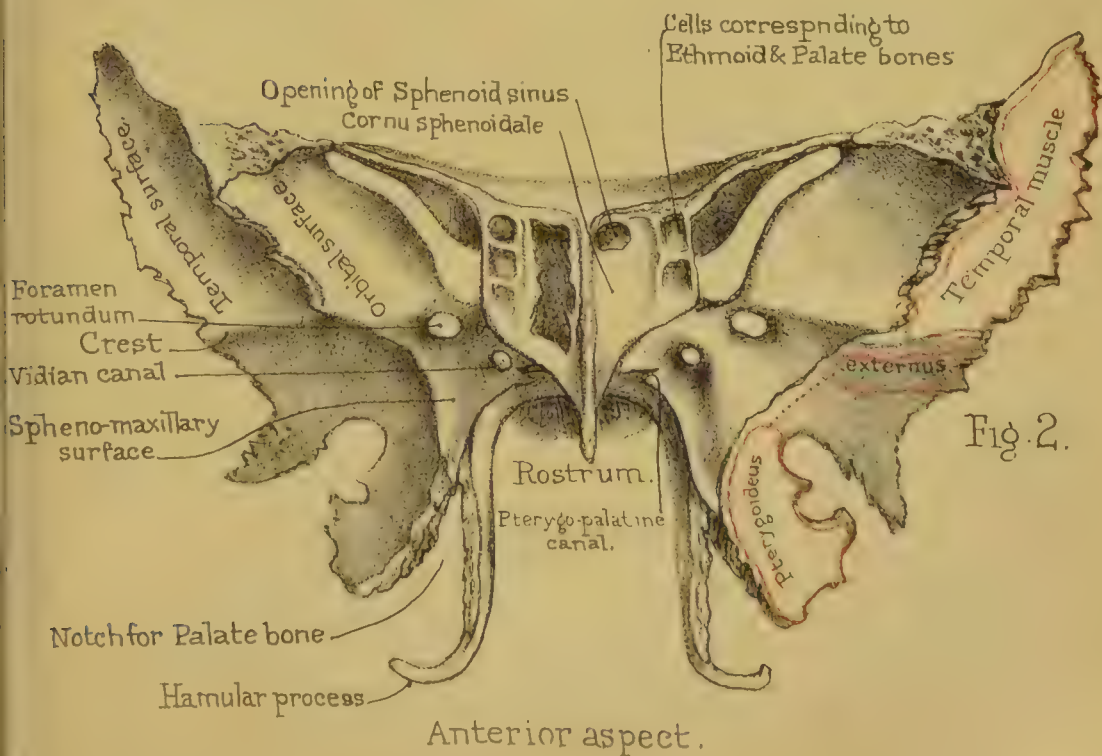
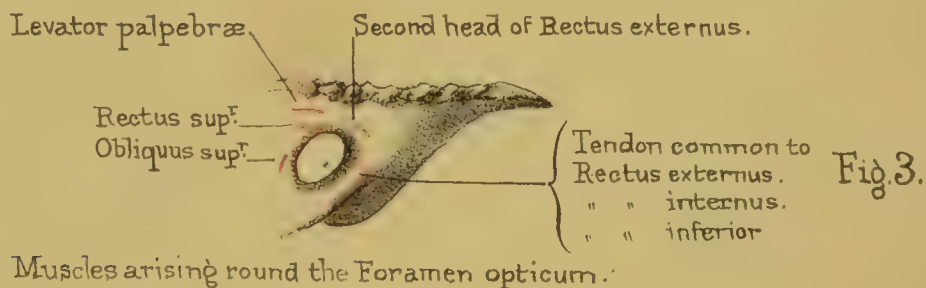
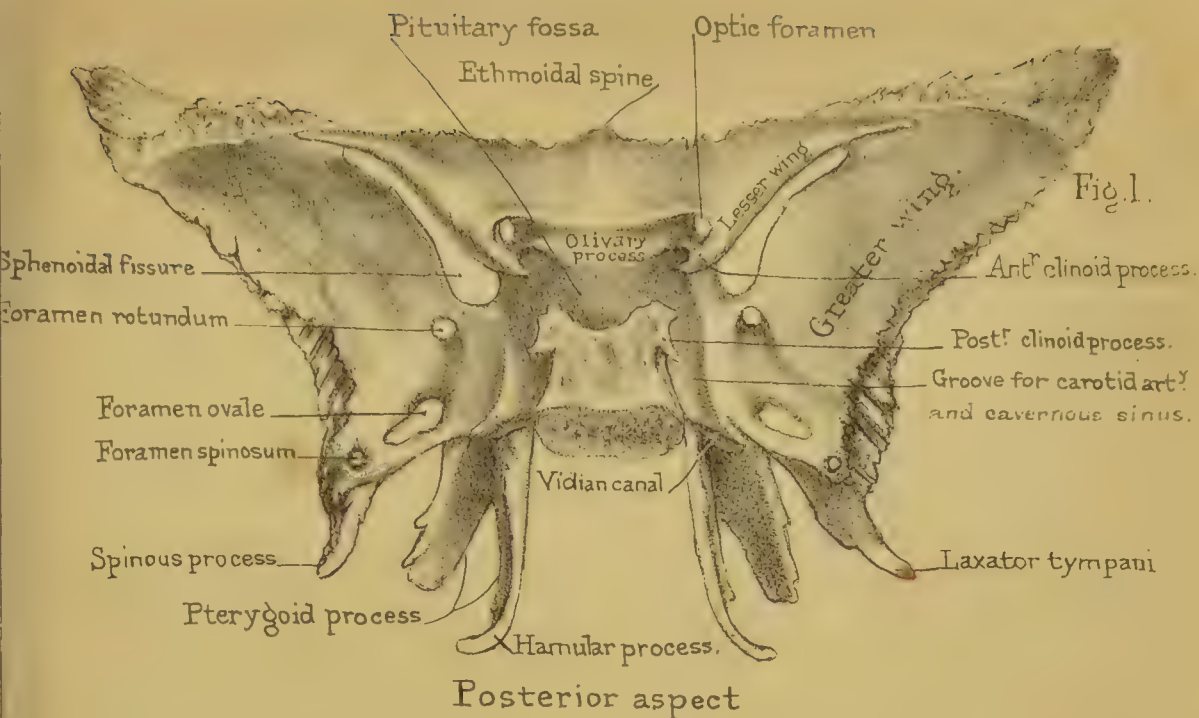
FIG. 16.
SPHENOIDAL
CELLS OR SINUSES.

We come next to the 'sphenoidal cells' or sinuses. These are large air cavities in the body of the sphenoid, generally two in number, and separated by a more or less complete perpendicular partition. (Plate XX. figs. 1 and 2.) Like the other air-cells in the bones of the skull, they are not developed in young subjects; but in the adult they gradually become large enough to excavate the whole body of the bone.* The air is admitted freely into them from the upper meatus of the nose through an opening in the front wall of each sinus; and they are lined with a prolongation from the nasal mucous membrane. This communication of the sphenoidal cells with the nasal cavities explains how bleeding from the nose may occur as a symptom of fracture through the base of the skull,—that is, through the body of the sphenoid.

Lastly, the sides of the anterior surface of the body are hollowed out into two or three small air-cells, one below the other. (Plate XIII. fig. 2.) Of these, the upper, one or more, are roofed in by corresponding cells of the ethmoid bone; and the lower by a corresponding cell in the orbital process of the palate bone.

The *inferior* surface of the body (Plate XIV. fig. 1) assists in forming the roof of the nasal fossæ; and the posterior part of this surface, continuous with the basilar process of the occipital bone, looks towards the upper part of the throat, and may therefore be called the 'guttural' surface. A portion of the vertical plate or

* In old skulls the cells often extend into part of the basilar process of the occipital bone. In the chimpanzee the sphenoidal cells extend far into the alisphenoid and pterygoid bones.



'rostrum' is seen here also; and you observe that it expands a little towards its base. Now it is this lower part of the rostrum which is connected with the vomer, and the mode of connection is rather singular. The rostrum fits into a deep cleft between the two plates or 'wings' of the vomer, and thus serves as a fulcrum from which this bone may pass forwards to form the septum of the nose. But the chief thing to notice on this surface is a process or scale of bone which projects horizontally inwards, on each side, from the base of the internal pterygoid plate. These are termed the 'vaginal processes,' and their free edges rise just enough to allow the edges of the vomer to slide beneath them. This is another contrivance for fixing the vomer. Lastly, these plates are each traversed by a small groove, or perhaps a complete canal, termed the 'pterygo-palatine canal,' for the transmission of the pterygo-palatine artery,* and a posterior branch (the pharyngeal nerve) from Meckel's ganglion.

So much for the anterior, posterior, superior, and inferior surfaces of the body of the sphenoid. All that we have to remark concerning the '*sides*' of the body is, that they are grooved for the carotid artery, and that the smooth plate of the body in front of the sphenoidal fissure contributes to form a part of the inner wall of the orbit. (Plate XXVI.)

LESSER WINGS. The lesser wings (processes of Ingrassias or orbito-sphenoids) project transversely from the upper part of each side of the body. (Plate XIII. fig. 1.) Their upper surface is smooth and flat, to support the anterior lobes of the brain; their lower surface overhangs the sphenoidal fissure, and forms the back part of the roof of the orbit: hence they are sometimes called the 'orbital wings.' Their anterior margins are serrated and articulate with the orbital plates of the frontal bone; their posterior margins are free, and in life fit into the great fissure (of Sylvius) between the anterior and middle lobes of the cerebrum. Their base is traversed by the 'foramen opticum,' for the passage of the optic nerve and ophthalmic artery into the orbit. This foramen should be described rather as a short canal

* This is a branch of the internal maxillary, and runs from before backwards to supply the top of the pharynx and the Eustachian tube.

directed outwards and forwards. Towards the 'sella Turcica' each wing projects considerably in the form of a blunt angle, termed the 'anterior clinoid process;' and between this and the body of the sphenoid there is either a deep notch or a complete ring for the internal carotid artery.

GREATER
WINGS.

The 'greater wings,' sometimes called the 'temporal' (or alisphenoids), project from the lower part of each side of the body. They present three surfaces, which respectively enter into the formation of the base of the cranium, the orbit, and the temple. Their 'cerebral surface' is concave, and marked by the convolutions of the middle lobe of the brain. Their 'orbital surface' is a smooth quadrilateral plate which forms more than half of the outer wall of the orbit. (Plate XVIII. fig. 2.) Of the four borders of this plate, notice that the superior is connected with the frontal bone, and the anterior with the malar bone; while the posterior and the inferior borders respectively enter into the formation of the 'sphenoidal' and 'sphenomaxillary' fissures. Their 'temporal surface' is divided into two unequal parts by a transverse 'crest' of bone; of these, the upper and larger one forms part of the temporal fossa, and gives origin to part of the temporal muscle: the lower one, which is more horizontal, forms part of the zygomatic fossa, and gives origin to one head of the 'pterygoideus externus.' The posterior angle of the great wing terminates in a sharp process termed the 'spinous process,' which fits in the angle between the squamous and petrous portions of the temporal bone, and gives attachment to the internal lateral ligament of the lower jaw, as well as origin to the 'laxator tympani.'

SPHENOIDAL
FISSURE.

The greater wings are separated from the lesser by a broad and long fissure, termed the 'sphenoidal fissure,' which leads from the base of the skull into the orbit, and transmits nerves to the eye and its appendages.* Immediately below the inner end of this fissure is the 'foramen rotundum,'

* The sphenoidal fissure, sometimes called the 'orbital,' or, again, the 'foramen lacrum basis cranii anterior,' gives passage to the third and fourth nerves, to the first or ophthalmic branch of the fifth, the sixth, a few filaments of the sympathetic nerve, and also to the ophthalmic vein.

which transmits the superior maxillary nerve. Farther back and more external is the 'foramen ovale,' which transmits the inferior maxillary nerve, the lesser petrosal nerve, and the small meningeal branch of the internal maxillary artery. Near the spinous process is the 'foramen spinosum,' through which the 'arteria meningeal media' enters the skull.*

PTERYGOID
PROCESSES.

The 'pterygoid processes' descend nearly perpendicularly from the under part of the bone,—one on either side. These remarkable processes answer three purposes:—1. Their internal plates bound the posterior openings of the nose; 2. They act as buttresses to support the upper jaw-bones; 3. They give origin to the powerful pterygoid muscles which produce the grinding movements of the lower jaw required for the mastication of the food. Each process consists of two plates, termed respectively the 'external and internal pterygoid plates.' These are united in front, but diverge from each other behind, so as to leave a deep interval, called the 'pterygoid fossa,' chiefly for the origin of the 'pterygoideus internus.' Immediately above this is a smaller fossa, termed, from its resemblance to a boat, the 'scaphoid fossa,' for the origin of the 'tensor palati' muscle. (Plate XIV. fig. 1.) At its lower part the pterygoid fossa presents a deep notch, which in the perfect skull is filled up by the tuberosity of the palate bone. Respecting the *internal* pterygoid plate, we observe that it forms the lateral and part of the superior boundary of the posterior opening of the nose; that it has a crescent-shaped margin above, to make room for the cartilage of the Eustachian tube; and that, below, it terminates in a pointed hook, termed the 'hamular process,' which makes a beautiful pulley, round which the tendon of the tensor palati plays. There is nothing to remark about the *external* pterygoid plate, except that it is broader than the internal, and that its outer surface forms the floor of the zygomatic fossa, and gives origin to the 'pterygoideus externus.' Lastly, at the base of the pterygoid pro-

* Besides the foramina in the greater wing described in the text, there is often one (near the outer edge of the sphenoidal fissure) which leads into the orbit, and transmits a branch of the middle meningeal artery. There is often another (between the foramen spinosum and ovale), through which a small vein passes; this is termed the 'foramen Vesalii.'

cesses, a long canal, the 'pterygoid' or 'Vidian,' runs from before backwards through the substance of the bone, and transmits the 'Vidian'* ('great petrosal') nerve and artery.

Look now at the anterior aspect of the pterygoid processes, and observe, on each side, a plate of bone, standing off like a side buttress to connect them with the greater wing. The plane of this plate forms a smooth surface, termed the 'spheno-maxillary,' and nearly corresponds in direction with that of the 'orbital surface' of the greater wing. (Plate XIII. fig. 1.) We draw special attention to this plate, and give it a special name, because it constitutes the posterior wall of a deep and important fossa, termed the 'spheno-maxillary,' which, in the perfect skull, intervenes between the sphenoid and superior maxillary bones.

CONNECTIONS OF THE SPHENOID. The sphenoid is connected with twelve bones, including all those of the cranium and five of the face. The 'body' is connected behind with the occipital bone by the basilar suture; in front with the ethmoid bone, the two palate bones, and the vomer. The 'lesser wing' is connected to the orbital plate of the frontal bone: the 'greater wing' is connected to the orbital plate of the frontal by a rugged surface of considerable extent, to the anterior inferior angle of the parietal bone, to the squamous and petrous parts of the temporal bone; and to the malar bone. Lastly, the pterygoid processes are connected with the palate bones.†

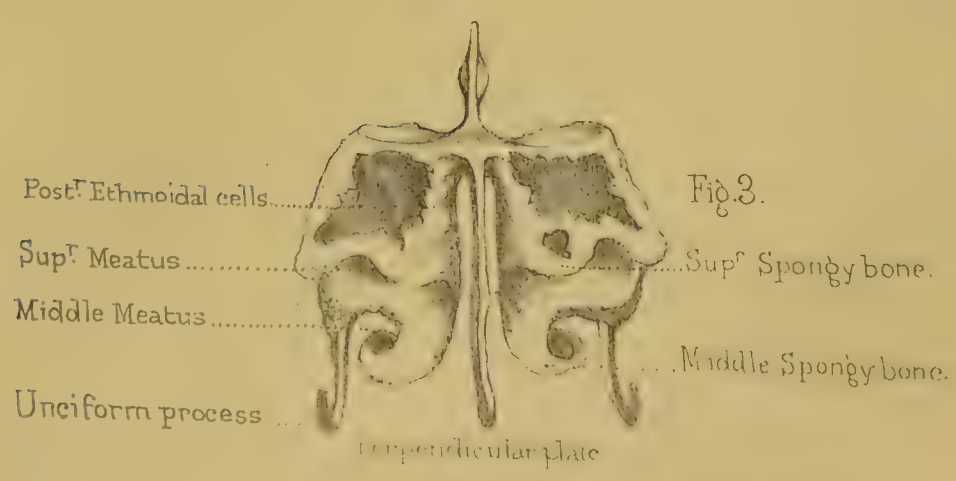
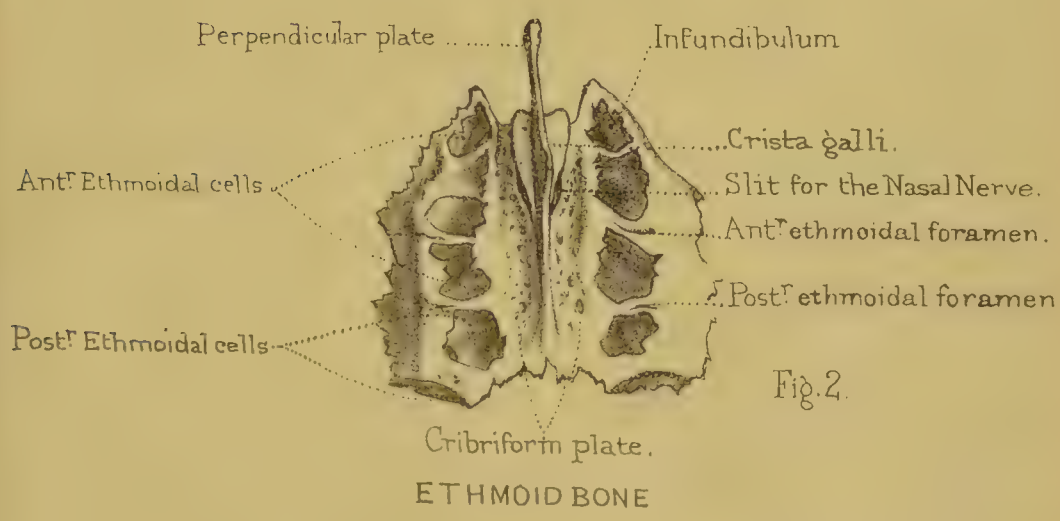
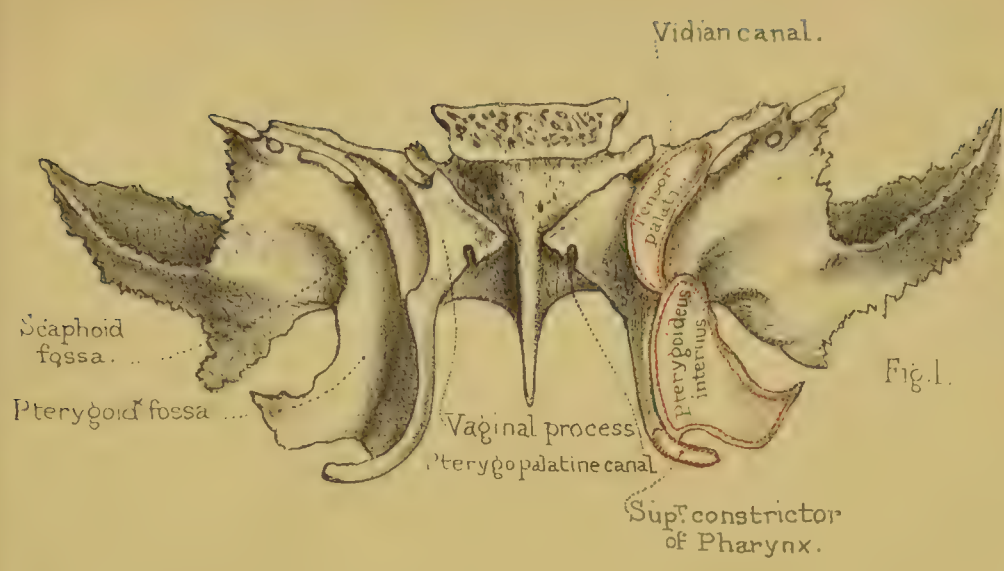
DEVELOPMENT
FROM FOURTEEN
CENTRES.

In the early foetus the sphenoid bone is divided into several parts. The posterior part of the body, termed by scientific anatomists the 'basisphenoid' or 'post-sphenoid,' is ossified from two centres, placed side by side in the sella Turcica. Later on another pair of centres (one on each side of the former) appear, making in all four for the basisphenoid part.

The greater wings, termed 'alisphenoids,' have each a distinct centre, from which the external pterygoid plates are also ossified.

* Vidus Vidius was a professor at Paris, and physician to François I^{er}.

† In some skulls, in which the malar bone does not enter into the composition of the spheno-maxillary fissure, the sphenoid meets the superior maxillary bone. In such exceptional skulls the sphenoid would be connected with seven bones of the face.



The front part of the body, termed ‘presphenoid,’ has two centres of its own; its lesser wings (orbito-sphenoids) each have one ossific nucleus.

Lastly, the internal pterygoid plates and the sphenoidal turbinated bones have each their separate nucleus of ossification. The bone then as a whole has fourteen centres of ossification.

As the preceding description may appear a little confusing to a beginner, the following plan will explain it better, and at the same time refresh the memory on the chief elements of the entire bone.*

PLAN OF THE OSSIFIC CENTRES OF THE SPHENOID BONE.

CORNU SPHENOIDALE (<i>Sphenoidal turbinated</i>).		CORNU SPHENOIDALE (<i>Sphenoidal turbinated</i>).	
1		1	
LESSER WING (<i>Orbito-sphenoid</i>).	FRONT OF BODY (<i>Presphenoid</i>).	LESSER WING (<i>Orbito-sphenoid</i>).	
1	1 1	1	
BACK OF BODY (<i>Basisphenoid</i>).			
GREATER WING (<i>Alisphenoid</i>) and external pterygoid plate.	2 2	GREATER WING (<i>Alisphenoid</i>) and external pterygoid plate.	
1		1	
INTERNAL PTERYGOID PLATE (<i>Pterygoid</i>).	INTERNAL PTERYGOID PLATE (<i>Pterygoid</i>).		
1	1		

* The cornua sphenoidalia begin to ossify about the time of birth, and do not unite to the body of the bone till the age of puberty. The internal pterygoid plates are developed from membrane, and begin to ossify about the fourth month. For full information on the development of the sphenoid bone, see Meckel's ‘Archiv,’ B. 1, and Quain's ‘Anatomy,’ 8th edition.

THE ETHMOID BONE.

(PLATE XIV. figs. 2 and 3.)

CONSTITUENT PARTS. This remarkably light and spongy bone contains the organ of smell. It occupies the interval between the orbital plates of the frontal bone, and enters into the formation of the cranium, the orbit, and the nose. It appears, at first sight, complicated; but it is simple when one understands the plan of it. It consists of a horizontal plate, which forms part of the base of the skull; of a central perpendicular plate which forms part of the septum of the nose; and of two 'lateral masses' containing the air-cells. Each of these must be examined separately.

HORIZONTAL OR CRIBRIFORM PLATE. The horizontal plate fits into the 'notch' between the orbital plates of the frontal bone; and completes the anterior fossa of the base of the skull. (Plate XXIII.) It is called the 'cribriform plate' (*cribrum*, ῥηθμός, a sieve), because it is perforated by holes for the passage of the olfactory nerves. High above it rises a crest of bone, termed, from its resemblance to a cock's comb, the 'crista galli.' This, which is a continuation of the perpendicular plate, gradually rises sharply from behind, swells out as it proceeds, and stopping suddenly short, presents a broken surface which is connected to the frontal bone.* The cribriform plate, observe, does not come up to the level of the lateral masses, but lies at the bottom of a deep groove ('olfactory groove'), which, being divided by the crista galli in the middle, forms in the perfect skull two recesses adapted for the lodgment and support of the olfactory lobes of the brain. The foramina at the bottom are arranged on each side in three somewhat irregular rows,—an outer, an inner, and a middle. Pass bristles down these holes, and you will find that the inner and the outer rows lead respectively to the 'olfactory canals' on the perpendicular plate and the upper spongy bones; while the

* The 'crista galli' serves for the attachment of the 'falx cerebri.' It varies in size, and has often a slight lateral inclination. Sometimes it contains an air-cell in its interior.

middle holes run simply through the cribriform plate * (Plate XX. figs. 1 and 2). Close to the 'crista galli' is a long 'slit,' rather than a hole, which gives passage, not to one of the olfactory nerves, but to the 'nasal nerve' (a branch of the first division of the fifth pair), which confers common sensation upon the mucous membrane as well as the skin of the nose.

PERPENDICULAR PLATE. The perpendicular plate descends from the cribriform plate and assists in forming the septum of the nose. Notice the numerous grooves and canals on its surface, for the passage of the olfactory nerves. Its connections are well shown in Plate XX. fig. 1. Behind, it is connected along a sloping line with the 'rostrum' of the sphenoid and the vomer: in front, it is connected with the nasal spine of the frontal and the crest of the two nasal bones, of which it mainly serves to support the arch. The triangular gap in the septum in the dry skull is filled up, in the recent state, by the central cartilage of the nose.

LATERAL MASSES. The 'lateral masses' of the ethmoid (fig. 17) are made up of irregular air-cells, surrounded by paper-like walls of bone, lined by the nasal mucous membrane. The cells are divided into two sets,—an anterior and a posterior; and the cells of one set do not communicate with those of the other. In the separated bone many of the cells are necessarily broken, because their walls, in the perfect skull, are completed by the adjoining bones. Thus, the front cells on the upper surface are roofed in by corresponding cells in the orbital plate of

FIG. 17.



TRANSVERSE SECTION, TO SHOW THE LATERAL AIR CELLS OF THE ETHMOID BONE,

* These three rows of holes correspond to the three sets of olfactory nerves: namely, those that ramify on the septum, those that ramify on the spongy bones, and those that supply the roof of the nose.

the frontal; those at the back of the bone are closed by the body of the sphenoid and the orbital process of the palate bone; those in front of the bone are walled in by the lachrymal; those below, by the superior maxillary bone. On the outer side of each lateral mass the cells are closed by a smooth and square plate of bone, termed the 'os planum,' belonging entirely to the ethmoid. This forms a large share of the inner wall of the orbit (Plate XXVI.), where it is easy to learn its connections with the surrounding bones, by tracing the sutures between them. Lastly, notice the two notches on its upper border, which contribute, with the frontal, to form the 'anterior and posterior ethmoidal (or orbital) foramina.'*

TURBINATED BONES AND MEATUS. On the inner aspect of the lateral mass we observe two thin plates of bone standing out, one below the other, and slightly curled, like a turbinated shell. These are the 'turbinated' or 'spongy' bones of the ethmoid (Plate XIV. fig. 3), and can be properly seen only in a divided skull. The 'superior' is the smaller of the two, and does not reach so far forward as the other, which is called the 'middle,' because there is a third or 'inferior turbinated' bone, still lower down in the nose; but this does not belong to the ethmoid. Now the spaces left between these turbinated bones and the lateral masses are called respectively the superior and middle 'meatus,' or passages of the nose. Each is distinct from the other, and leads to its own particular cavities, and to no other. The superior meatus, being farther back than the middle, leads into the 'sphenoidal sinus,' and into the 'posterior ethmoidal cells.' The middle meatus leads into the 'anterior ethmoidal cells,' and also to the frontal cells, along a funnel-shaped canal (termed the 'infundibulum') which traverses the foremost of the ethmoidal. (Plate XX. fig. 2.)

The chief use of the turbinated bones is to afford additional surface for the subdivisions of the olfactory nerves: for this purpose they are studded with grooves and canals, through which the nerves come down from the cribriform plate and spread out upon the mucous membrane. In man, the arrangement of these bones

* The 'anterior' transmits the nasal nerve and the anterior ethmoidal vessels; the 'posterior' gives passage to the posterior ethmoidal vessels.

is very simple; they make only a single curve. But in animals remarkable for their sense of smell, these turbinated bones make rolls within rolls; or, as in the seal, they subdivide into a multitude of plates, like the separated leaves of a book, in order to afford a vast surface for the application of the olfactory membrane—a surface which has been calculated to be not less than 126 square inches in each nostril.

UNCIFORM PROCESS. Lastly, from the anterior part of each lateral mass an irregular plate of bone descends almost perpendicularly, and terminates in a kind of hook; hence it is called the ‘unciform* process’ (Plate XIV. fig. 3). By referring to Plate XX. fig. 2, it is seen that this process is connected with the inferior spongy bone, and with the thin walls of the ‘antrum’ of the superior maxillary bone; its chief purpose being to assist in narrowing the orifice of this great air-cavity.

CONNECTIONS. The ethmoid is connected with thirteen bones, namely,—behind, with the sphenoid and two palate bones; above, with the frontal; below, with the two superior maxillary; in front, with the two lachrymal bones. The perpendicular plate is connected behind with the vomer, and in front with the two nasal bones. Lastly, the unciform process on each side is connected with the inferior spongy bone and the superior maxillary.

DEVELOPMENT. Until the middle of foetal life the ethmoid is all cartilage. Ossification begins about the fifth month, by a centre for each of the lateral parts, and gradually extends into the two upper turbinated bones (ethmo-turbinals). Within a year after birth another centre appears for the perpendicular and cribriform plates (mesethmoid). An arrest in the progressive ossification of the perpendicular plate occasions a ‘pug nose.’ In the foetus at birth there are no ethmoid cells; these are not formed till the fourth or fifth year.

* The ‘unciform process’ is almost always broken in taking the skull to pieces; but it is evident enough in a good section of the nasal cavities.

BONES OF THE FACE.

THERE are fourteen bones of the face ; namely, the two superior maxillary, the two malar, the two nasal, the two lachrymal, the two inferior spongy, the two palate, the vomer, and the inferior maxilla.

SUPERIOR MAXILLARY BONE.

(PLATE XV.)

CONSTITUENT PARTS. This bone gives much of its character to the human face, and forms the greater part of its framework. It is exceedingly irregular in shape, and, besides forming sockets for the teeth, enters into the composition of the nose, the orbit, the cheek, and the palate. For convenience of description, we divide it into a ‘body,’ which is hollowed out into a large air-cavity, called the ‘antrum,’ and four outstanding ‘processes ;’ namely, the ‘alveolar,’ which holds the teeth ; the ‘palatine,’ which forms part of the hard palate ; the ‘nasal,’ which assists in forming the nose ; and the ‘malar,’ which helps to form the prominence of the cheek.

BODY. WALLS OF THE ANTRUM. Let us take the ‘body’ first, and learn its various relations well, for it is a part of great surgical interest, being liable to many diseases requiring surgical operations. The first thing to observe is, that the walls which bound its cavity have *four* aspects : one—namely, the front—looks towards the cheek ; another, the upper, looks towards the orbit ; a third, the inner, looks towards the nose ; and a fourth, behind, looks towards the zygomatic fossa. Therefore, when a morbid growth forms in the antrum, and distends it, any one or more of these walls may be protruded. They are all very thin, the orbital

especially ; but it is worth remembering that they are thicker in the child than in the adult.

ANTRUM. AN-TERIOR WALL. The anterior wall of the 'antrum' is that which is generally removed to take out a morbid growth from the interior, and through which we tap the antrum to let out pus, or any fluid that may have accumulated there ; cysts in the antrum being by no means uncommon. There is a depression in it, called the 'canine fossa' a little outside the eminence of the canine tooth ; and above this is the 'infra-orbital foramen,' or termination of the 'infra-orbital canal,' which transmits the 'infra-orbital' nerve and artery. The canine fossa gives origin to the 'levator anguli oris.' Above the infra-orbital foramen arises the 'levator labii superioris,' and more internally the 'compressor narium.'

ANTRUM. POSTERIOR WALL. The posterior wall of the antrum is convex, and bulges into the zygomatic fossa.* There are several small holes in it, leading to canals ('dental canals') for the transmission of the posterior dental branches of the superior maxillary nerve, and the superior dental branches of the internal maxillary artery. Lower down it has a very rough surface, just behind the wisdom tooth, called the 'tuberosity,' by which it is firmly connected to the palate bone ; and along the inner edge of this surface (fig. 2) is a groove, which, with the perpendicular plate of the palate bone, forms the 'posterior palatine canal,' for the passage of the descending palatine nerve and artery.

ANTRUM. SUPERIOR WALL. The superior wall or roof of the antrum slopes downwards and outwards, and forms the floor of the orbit. Like the other walls of the antrum, it is thin enough to be translucent. Notice here the 'infra-orbital canal,' for the passage of the superior maxillary nerve. It commences behind as a groove, but soon becomes a canal, which terminates on the front wall of the antrum, just below the edge of the orbit. A little before its termination, the main canal gives off one or sometimes two smaller ones, not always visible, termed the 'anterior dental canals.' These

* Blandin ('Anat. Topogr.' p. 44) relates a case in which a tumour, originating in the antrum, made its way into the zygomatic fossa, and caused a swelling in the temple.

run down in the very substance of the front wall of the antrum, to transmit blood-vessels and nerves to the two incisor, the canine, and the first bicuspid teeth. To see these canals it is necessary to introduce a bristle as a guide, and then to rasp away the front wall of the bone. Near the lachrymal groove may sometimes be seen a small depression, indicating the spot where the 'inferior oblique' muscle of the eye arises. This is the only muscle of the orbit which takes origin from the front; all the others arise from the back part, around the optic foramen. In the perfect skull (Plate XVIII.) observe that the upper wall or 'orbital plate' of the antrum is connected on its inner side with the lachrymal, ethmoid, and palate bones; but that on its outer side it forms one of the margins of the 'spheno-maxillary fissure,' at the back of the orbit.

ANTRUM. IN-
TERNAL WALL.
ORIFICE OF
ANTRUM.

On the inner or 'nasal wall' of the antrum, the first thing to notice is the orifice of the antrum itself. (Plate XV. fig. 2.) In the separate bone, this orifice is very irregular, and large enough to admit the end of a finger;* but in the perfect skull (Plate XXVI.) it is very much closed in by thin plates from the ethmoid, the palate, and the inferior spongy bones. In the recent state, indeed, the orifice is generally so contracted by a fold of the mucous membrane of the nose, that it will only just admit the passage of a crow-quill. Observe, moreover, that the orifice is not near the bottom of the antrum, but very high up: the consequence of this is, that when fluid collects in the antrum it cannot run out until the antrum is nearly full, or until the head is inclined horizontally with the opposite cheek downwards.

ANTRUM,
CAVITY OF.

So much for the four walls of the antrum. Now, study the size and form of the cavity itself. The 'maxillary sinus,' or 'antrum of Highmore,'† is by far the largest of the air-cells in the bones of the head. It is lined by nasal mucous membrane, and is large enough to hold a musket-ball

* Sometimes there are two openings, separated by the thin plate (unciform process) which descends from the ethmoid bone.

† Nathaniel Highmore was an English anatomist, born 1613, died 1684, who wrote much about the diseases of the antrum. He did not discover the antrum. It was known to Galen as the 'Sinus maxillaris.'

with ease. Mr. Guthrie * says he has known a ball lodged in the antrum for months, and even for years, before it was removed. Mr. Jarjavay † speaks of a ball having lodged for eleven years in the antrum, and having finally made its way out through the roof of the mouth. However, it varies in size, and somewhat in shape, in different persons; but, as a rule, it has the form of a triangular pyramid, with the base towards the nose, and the apex towards the malar bone. Thin plates of bone often project into the antrum, making a kind of recess or pocket here and there; ‡ and the fangs of one or more of the molar teeth generally project into it, either quite bare, or covered by a thin scale of bone. Hence the practice, adopted by some surgeons, of drawing one of these teeth, say the first or second molar, to let out matter from the antrum. Again, the fangs of decayed or otherwise injured molar teeth are liable to set up disease in the antrum; and this is the explanation commonly given why morbid growths arise in the antrum more frequently than in any other of the air-cavities of the nose.

The following case gives a good idea of the extent of the antrum: — ‘A lady suffering from tooth-ache submitted to the extraction of the canine tooth of the upper jaw, with which a portion of the alveolar process was removed, making an aperture in the antrum, from which a watery fluid constantly issued. The patient, desirous of ascertaining the source of the discharge, took a pen, and having stripped off the barbs from the feathered part, found that the whole of it, full six inches long, could be introduced into the cavity. At this she was greatly terrified, believing it must have gone into the brain. She consulted Highmore, who explained to her that the pen had turned spirally within the sinus, and he, besides, counselled her to submit with patience to the inconvenience of the discharge from the cavity.’§

ALVEOLAR PRO-
CESS AND TEETH.

The alveolar process is a thick and strong ridge of bone, curved so as to form with that of the other side the elliptical figure of the dental arch. It consists of two plates, an outer and an inner, connected by numerous septa

* ‘Commentaries,’ p. 528.

† ‘Anatomie Chirurgicale.’

‡ See a curious case by Catlin, ‘Trans. Odontolog. Soc.’ vol. ii. 1857.

§ Drake’s ‘System of Anatomy,’ 8vo. 1707.

which form the sockets (alveoli) of the teeth. The inner plate is the stronger of the two, therefore in drawing a tooth care should be taken to incline it a little outwards. The outer plate is marked by eminences corresponding to the roots of the teeth; the eminence of the canine tooth being especially marked. The alveolar process contains, in the adult, sockets for eight teeth; namely, two 'incisors,' one 'canine,' two 'bicuspid or premolars,' and three 'molars.' Thus the dental formula of the adult human skull is—

$$-i.\frac{2+2}{2+2}, \quad c.\frac{1+1}{1+1}, \quad p.\frac{2+2}{2+2}, \quad m.\frac{3+3}{3+3}=32.$$

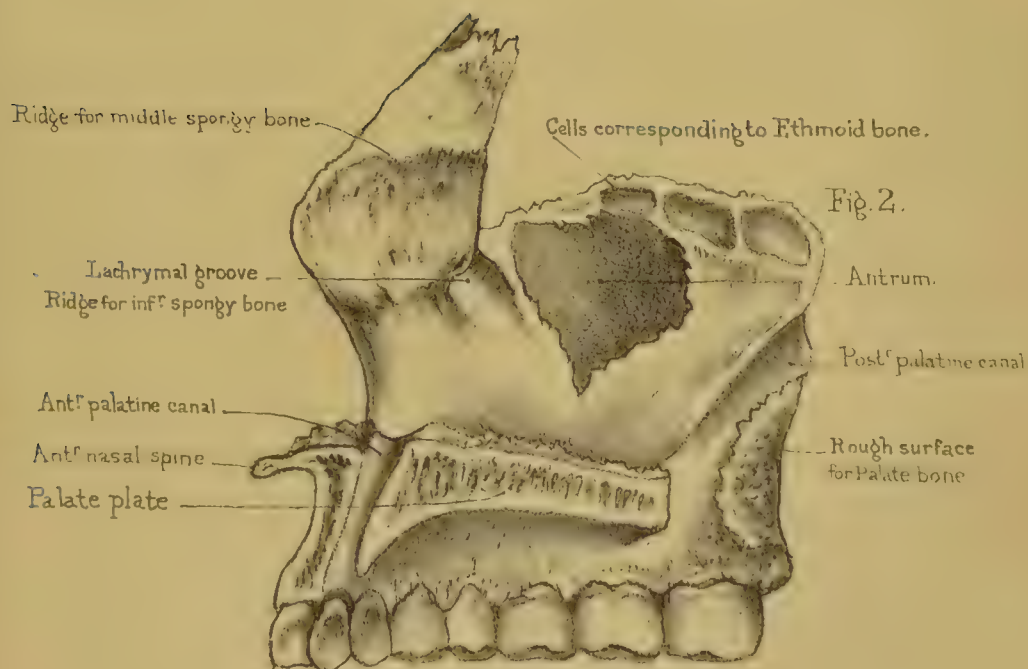
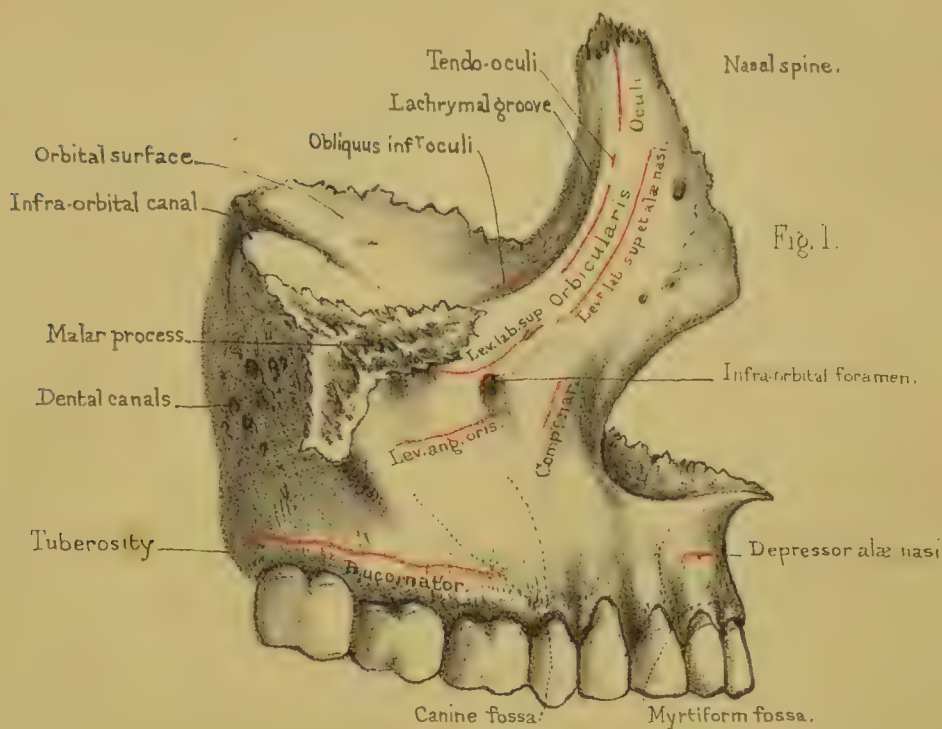
In the child, before the seventh year, there are only five sockets.

The formula for the 'milk dentition' is—

$$i.\frac{2+2}{2+2}, \quad c.\frac{1+1}{1+1}, \quad m.\frac{2+2}{2+2}=20.$$

SOCKETS OF THE TEETH. The sockets correspond in number and size to the fangs of the teeth they receive. They vary in depth in different instances. The deepest of all is the socket of the canine tooth: this is often $\frac{7}{10}$ of an inch in depth in the dry bone. The first two of the molars of the upper jaw have generally each three fangs, and as many sockets. Of these fangs, two are external, one internal. Irregularities in the shape and the direction of the fangs, whether diverging too much or converging, lead to unavoidable evils when it is necessary to extract them. Either a fang breaks, or part of the alveolus must be extracted with the fang. One cannot foresee this. Hence it follows that, now and then, even the most skilful operators break teeth or extract portions of bone. At the bottom of each socket is a minute hole, through which the vessel and nerve come up to the fang; and there are also numerous holes in the bony partitions between the sockets, through which vessels come to supply the gums and the periosteum. These are the sources of the bleeding after the extraction of a tooth. The teeth are fixed, not only by the closely fitting socket, but also by the very vascular membrane, the periosteum, which lines the socket and adheres closely to the fang. This periosteum not only retains the teeth

SUPERIOR MAXILLARY BONE.





in their place, but maintains their vitality, and, being elastic, breaks shocks which would otherwise be communicated to the jaws. When the dental periosteum inflames, the tooth is partly lifted out of its socket, and the jaws cannot be closed without pain. If the inflammation goes on to the formation of matter, the periosteum quits its hold of more or less of the fang, and abscess in the socket is the result. The matter then makes its way out by the side of the tooth, or through a small hole formed by ulceration in the alveolar wall; and a gumboil is the result. In the dry bones, most of the teeth fall out, because the periosteum shrinks, and thus the sockets become too large.

The alveolar process gives origin to two muscles (Plate XV. fig. 1), namely, to the ‘buccinator’ above the three molar teeth, and to the ‘depressor alæ nasi’ above the incisor teeth, where there is a little depression, termed the ‘myrtiform fossa.’

NASAL PROCESS. The nasal process ascends nearly perpendicularly, in a line with the canine tooth, to abut, by means of a very rough suture, upon the internal angular process of the frontal bone. It supports the true nasal bones, and contributes to form the inner margin of the orbit. The principal point concerning the nasal process is the deep groove which runs almost vertically behind its orbital margin. It is called the ‘lachrymal groove.’ In the perfect skull it is converted into a complete canal by a corresponding groove in the lachrymal bone and a small portion of the inferior spongy bone. The canal thus completed is for the lodgment of the ‘lachrymal sac’ and ‘nasal duct,’ which convey the tears into the inferior ‘meatus’ of the nose. It is about the size of a common goose-quill. When, from inflammation or other cause—such as a tumour—the canal becomes obstructed, the tears necessarily flow over and run down the cheek. To obviate this, it is often requisite to puncture the lachrymal sac, and introduce a style into the canal. Therefore one must know well the direction of the canal. It runs from above downwards, and with a slight inclination backwards. On the outer surface of the nasal process we observe the prominent ridge which forms the inner margin of the orbit. This gives origin to the ‘tendo oculi’ or ‘palpebrarum’ and the ‘orbicularis oculi.’ A little in front of

this the 'levator labii superioris et alae nasi' arises. On the inner surface we observe the two ridges to which the inferior and middle spongy bones are attached, and also the smooth surfaces between the ridges which respectively form part of the inferior and middle 'meatus' of the nose. Near the top the nasal process often closes in one of the anterior ethmoidal cells. In front the nasal process presents a sharp crescent-shaped margin, which, with the similar one on the opposite bone, bounds the anterior opening of the nose, and gives attachment to the lateral cartilage.

PALATINE PROCESS.

The palatine process extends horizontally inwards, to form the anterior two-thirds of the hard palate, and the floor of the nose; the posterior third being completed by the palate bone. It is slightly arched from before backwards and is thicker in front, near the alveolus, than behind. On the palatine surface (Plate XXIV.) we observe—1, the palatine groove for the descending palatine vessels and nerve; 2, the numerous foramina which transmit vessels into the bone; and 3, the pits made by the palatine glands. On the upper or nasal surface there is nothing to notice, more than that it is smooth and slightly concave. By adjusting the two superior maxillary bones together, you find that the palatine processes are connected in the middle line by a very rough suture (palatine suture); and that they rise towards the nose in a kind of crest, which articulates with the vomer, and forms as it were a base for the bony septum of the nose. (Plate XX. fig. 1.) This crest projects in front in the shape of a sharp spine (the 'anterior nasal spine'), which serves for the attachment of the cartilaginous part of the septum. In this palatine suture, immediately behind the middle incisor teeth, we observe the 'anterior palatine canal.' (Plate XXIV.) Towards the palate this canal has, at first sight, only one large orifice; but if we look to the bottom of it, we shall probably find four minute openings. Two of these* lie in the middle line, one behind the other, and transmit the naso-palatine nerves; the other two much larger, are situated one on each side the middle line; they

* These 'incisor' foramina are sometimes called the foramina of 'Scarpa.'

lead into the floor of each nostril, and transmit the anterior palatine arteries.*

MALAR PROCESS. The malar process stands off from the outer side of the antrum. It is remarkably thick and strong, and is connected, by a very rugged triangular surface, with the malar bone. Observe that the malar process is situated just over the first and second molar teeth, and is therefore well calculated to resist pressure in mastication. When we crack a nut, we instinctively place it under these teeth.

CONNECTIONS. The superior maxilla is connected with nine bones, as follows:—with the malar, the frontal, the nasal, the lachrymal, the vomer, the inferior spongy, the palate bone, its fellow, and lastly, the ethmoid. We mention this bone last of all, because we wish to direct attention to a fact which we have hitherto omitted to notice, that some of its cells are closed in by half cells usually seen along the orbital plate of the superior maxillary bone. (Plate XV. fig. 2.)

DEVELOPMENT. The ossification of the upper jaw begins so soon (as early as the sixth or seventh week), and proceeds so quickly, that the number of its independent centres has not yet been accurately determined. It appears to have five distinct centres, one for the alveolus behind the incisors, one for the palatine process, one for the floor of the orbit and malar process, a fourth for the portion in front of the antrum with the nasal process, and lastly, a very distinct centre † which includes the sockets of the two incisor teeth. In animals this remains a permanently distinct bone, called the ‘pre-maxillary,’ or ‘inter-maxillary.’ Indeed, in most human skulls, if not very old, one can trace the remains of the pre-maxillary suture. (Plate XXIV.) It runs outwards from the anterior palatine canal, and then through

* These lateral foramina are sometimes called the foramina of ‘Stenson.’ The description in the text concerning the anterior palatine canals applies to twenty out of forty skulls examined. Their disposition, in other cases, is very apt to vary, both as to number and size. It was Scarpa (‘Annot. Anatom.’ lib. ii. p. 75) who first pointed out the varieties in these canals. In many instances one of the canals is absent; or, if present, not pervious throughout. For a more complete explanation of this question, see ‘Quain’s Anatomy.’

† This part, in man, was first pointed out by the poet Goethe.

the alveolar border of the jaw, invariably between the second incisor and the canine tooth; and here we lose all trace of it. This is interesting surgically. In cases of double hare-lip, where the fissure is not confined to skin, the pre-maxillary bones on each side fail to unite with the rest of the upper jaw, and often project in a hideous manner through the fissure of the lip. When removed by operation, these bones are always found to contain the capsules of the four incisor teeth.*

MALAR BONE.

(PLATE XVII. fig. 3.)

The malar bone forms the prominence of the cheek, a part of the margin and wall of the orbit, and the greater portion of the zygomatic arch. It is remarkably thick and strong, in order to resist injury, to which the face, in this situation, is so exposed. We divide it into an anterior or *subcutaneous* surface, a superior or *orbital*, and a posterior or *zygomatic*.

THREE SUR-
FACES.

On the *subcutaneous* surface there is nothing to observe except the orifice of one of the 'malar canals,' and that it gives origin to the 'zygomaticus major' and 'minor' muscles.

The *superior* surface forms part of the outer wall of the orbit, a small part of its floor, and, generally speaking, the corner only of the speno-maxillary fissure.† There are usually two 'malar canals' to be seen on it. By introducing bristles, it will be found that one of these leads to the subcutaneous surface; the other, to the zygomatic surface.‡

* For the most recent investigations concerning the 'Formation and Early Growth of the Bones of the Human Face,' see a very interesting and elaborate paper by Mr. G. W. Callender in the 'Philosoph. Trans.' for 1869.

† From an examination of many skulls, I find that the malar bone is excluded from the speno-maxillary fissure more frequently than is generally supposed. This exclusion is effected in one of two ways; either by the immediate junction of the superior maxillary and sphenoid bones, or by the interposition of a little 'Wormian' bone just at the angle of the fissure.

‡ These malar canals transmit cutaneous nerves which proceed from the orbital

The *posterior* surface is very concave, in order to form the anterior wall of the zygomatic fossa.

THREE BORDERS. The malar bone has three free borders. One forms at least a third of the margin of the orbit, and reaches as far inwards as the infra-orbital canal, giving origin to a few fibres of the 'levator labii superioris'; a second forms the upper edge of the zygomatic arch, and running upwards becomes continuous with the temporal ridge at the external angular process of the frontal bone, this border gives attachment to the 'temporal fascia'; a third forms the lower edge of the arch, and gives origin to the 'masseter' muscle. (Plate XIX. fig. 2.)

CONNECTIONS. The malar bone is connected with four bones : namely, by a broad and very roughly serrated surface, with the superior maxillary; by suture, with the external angle of the frontal, the orbital plate of the sphenoid, and the zygomatic process of the temporal. These several connections are so strong, that the bone cannot be driven inwards towards the orbit, and fractures of it are very rare.

DEVELOPMENT. It is developed from a single centre of ossification, which appears about the eighth week.*

N A S A L B O N E.

(PLATE XVIII. fig. 3.)

The nasal bones, situated one on either side, occupy the space between the nasal processes of the superior maxillary, and, together, complete the bridge of the nose. Their length, breadth,

branch of the superior maxillary nerve to the cheek, and the zygomatic fossa respectively.

* It has been recently asserted that a second centre exists (Darwin, 'On the Descent of Man,' vol. i. p. 124). At all events, in some ancient and savage human skulls, a transverse suture is seen running from before backwards, so as to separate the lower border from the rest of the bone. It is most frequent in the skulls of the Dyaks of Borneo. (See No. 5495 G. 'Osteological Series,' Museum of the Royal College of Surgeons.)

and degree of inclination, determine the shape of the nose. We have to examine their anterior and posterior surfaces, and their four borders.

SURFACES.

Their *anterior* surfaces are subcutaneous, convex, and present the orifices of one or more canals, for the transmission of blood-vessels. Their *posterior* surfaces are concave, form part of the roof of the nose, and are each marked by a groove for the passage of the external branch of the nasal nerve.

BORDERS.

Their *upper* borders are broad, serrated, and firmly articulated with the frontal bone. Their *lower* borders are thin and free in the dry bone, but connected in the recent subject with the lateral cartilages of the nose. Each has, generally, a little notch in it, through which the external branch of the nasal nerve comes to supply the skin at the tip of the nose. Their *outer* borders are serrated, and slightly sloped, to articulate with, and be supported by, the nasal processes of the superior maxillary. Their *inner* borders articulate with each other, in the middle line, along the 'nasal suture.' From the under surface of this suture a high 'crest' of bone projects. By putting the bones together, it is seen how their crests form the beginning of the bony septum of the nose, and how they articulate with the nasal spine of the frontal bone, and the perpendicular plate of the ethmoid. (Plate XX. fig. 1.) Hence, you cannot have a fracture with depression of the nasal bones, without a fracture of the perpendicular plate of the ethmoid. In some rare instances, the injury extends through the perpendicular plate of the ethmoid to the base of the brain. Observing the great strength of the nasal bones and the massive arch they form, how the sides of this arch are supported by the nasal processes of the superior maxillæ, while the centre is propped up by the nasal spine of the frontal bone, and the perpendicular plate of the ethmoid (Plate XXI. fig. 2), one can readily understand what makes the arch so strong, and why the bones are so seldom broken. A pretty good proof is given of the strength of the arch, when one sees a mountebank support upon it, with impunity, a heavy ladder, with the additional weight of a man upon the steps

CONNECTIONS. The nasal bone articulates with four others, namely, its fellow, the superior maxillary, the frontal, and the perpendicular plate of the ethmoid.

DEVELOPMENT. Each nasal bone is developed from a single centre of ossification, which appears about the eighth week.

LACHRYMAL BONE.

(PLATE XVII. fig. 4.)

The lachrymal bones are situated, one on each side, on the inner wall of the orbit. They are exceedingly thin and delicate, and shaped somewhat like a nail; hence the name ‘os unguis.’ In old skulls, they are often as thin as silver paper, and sometimes perforated. One surface looks towards the orbit; SURFACES. the other towards the nose. One of these bones is seen *in situ* in Plate XVIII. fig. 2.

The external or *orbital* surface has a vertical ridge upon it which terminates below in a small lancet-like process or tongue, termed ‘hamulus,’ so as to fit into the angle between the inferior turbinated bone and the superior maxillary (Plate XX. fig. 2). In front of this is a groove (‘lachrymal groove’), which, together with the groove on the nasal process of the superior maxilla, forms the canal for the lachrymal sac. The ridge itself gives origin to the ‘tensor tarsi.’ The bone behind the ridge is smooth, slightly concave, and forms part of the inner wall of the orbit.

The internal or *nasal* surface presents a slight furrow corresponding to the external ridge. The surface in front of this forms part of the middle meatus of the nose; that behind it always covers the anterior cells of the ethmoid bone, and sometimes a small cell or two in the frontal bone.

CONNECTIONS. By examining the orbit (Plate XVIII. fig. 2), you observe that the lachrymal bone is somewhat

square, and that it articulates by suture with the frontal above, the ethmoid behind, the superior maxillary in front and below. But this is not all. The lower edge of the bone has a little triangular 'tongue,' which articulates with what is called the 'lachrymal process' of the inferior turbinated bone. (Plate XX. fig. 2.) So, then, it articulates with four bones.

DEVELOPMENT.

It has one centre of ossification, which appears about the eighth week.

PALATE BONE.

(PLATE XVI. figs. 1, 2, 3.)

The two 'palate bones,' one on each side, are wedged in between the pterygoid process of the sphenoid and the superior maxillary bones. They form part of the nasal fossæ, of the orbits, and of the palate. As the palate bone somewhat resembles the letter L in shape, we can divide it, for convenience of description, into a horizontal and a vertical plate.

HORIZONTAL PLATE. The horizontal plate completes the bony palate by fitting on to the palate plate of the superior maxillary bone. Its under surface (Plate XVI. fig. 3) presents a transverse ridge, more or less marked in different bones, for the insertion of the aponeurosis of the 'tensor palati.' In front of this ridge and towards its outer end we observe the orifice, more or less complete, of the 'posterior palatine canal,' for the transmission of the descending palatine vessels and the larger descending palatine nerve from Meckel's ganglion. The anterior edge of this plate is serrated and cut obliquely, so as to articulate with, and be supported by, the palate plate of the superior maxilla. The posterior edge is smooth and concave, and gives attachment to the soft palate. The inner edge firmly articulates with its fellow, by means of a 'median crest' raised up towards the nose, precisely like the corresponding parts in the superior maxillary bones (see

Plate XX. fig. 1): this crest serves to support the vomer, and forms a basis for the septum of the nose. Behind, it terminates in a pointed process, termed the 'posterior nasal spine' (Plate XXIII.), which gives origin to the 'azygos uvulæ' muscle. Concerning the upper surface of the plate we have to notice that it is smooth and slightly concave, in order to form part of the floor of the nose.

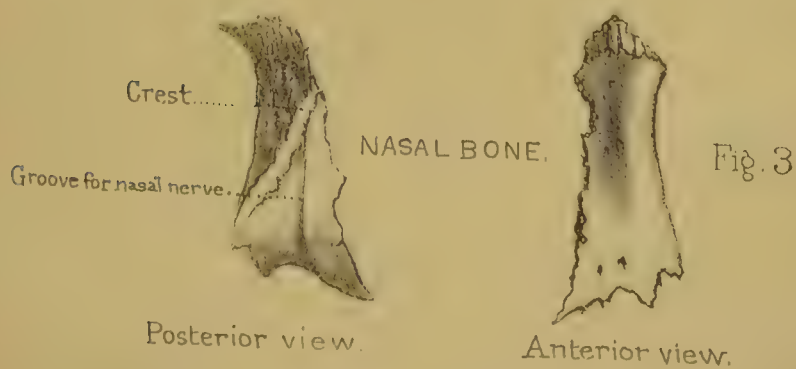
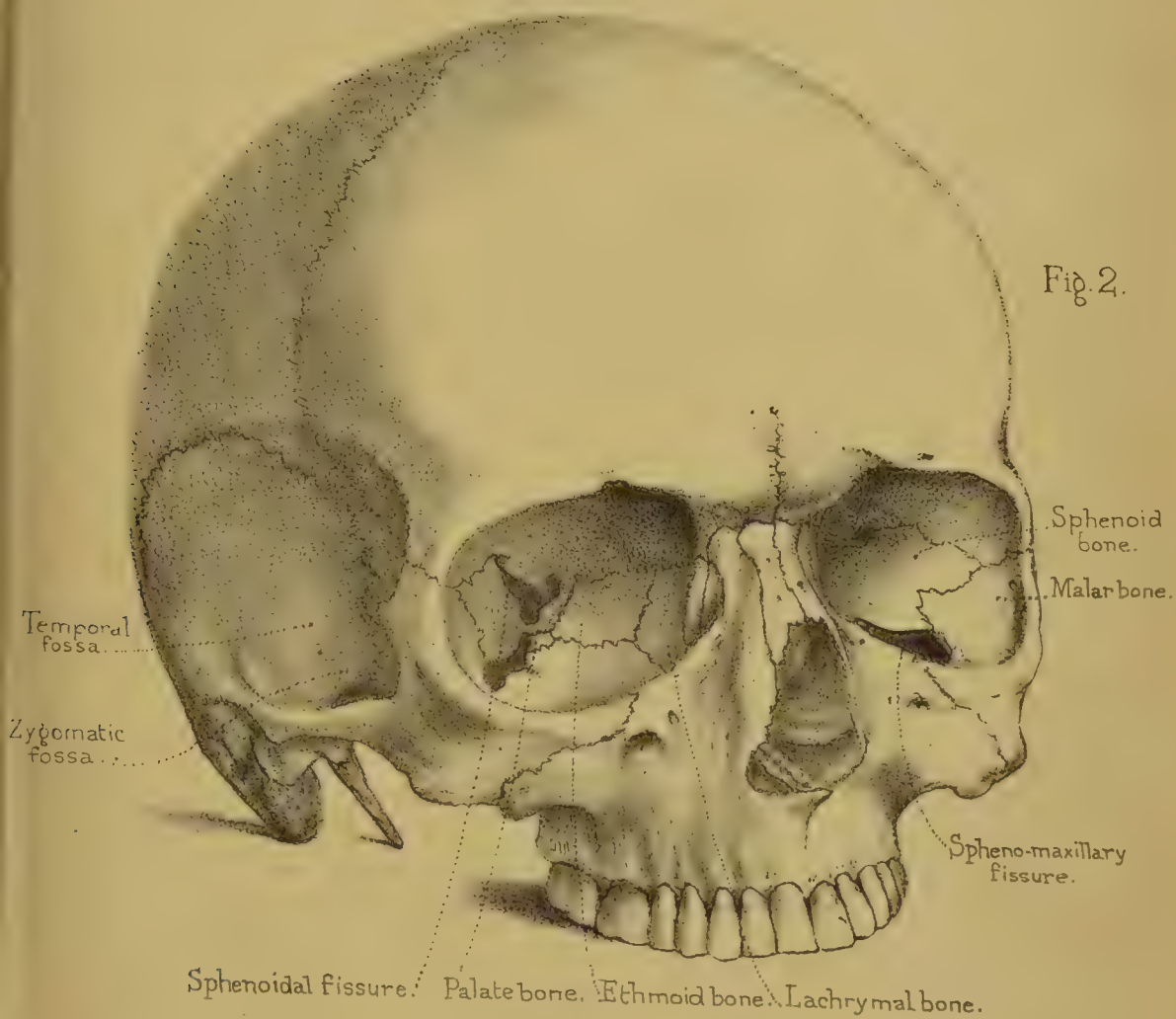
VERTICAL PLATE. The vertical plate of the palate bone contributes to form the outer boundary of the nasal fossa. On its inner surface (Plate XVII. fig. 1) is a 'ridge' for the attachment of the inferior turbinated bone. The surfaces above and below this ridge, respectively, form part of the middle and inferior 'meatus' of the nose. Still higher, is a ridge for the middle turbinated bone. On its outer surface we observe a vertical groove, which either alone, or in conjunction with the superior maxilla, forms the 'posterior palatine canal,' for the transmission of the descending palatine vessels and the large palatine nerve. The front part of the vertical plate fits along the inner wall of the antrum of the superior maxilla, and helps to contract the lower and back part of the orifice of the antrum. This part, however, is very fragile, and is generally broken in separating the bones.

TUBEROSITY, OR PYRAMIDAL PROCESS. From the angle formed by the horizontal and vertical plates projects backwards what is called the 'tuberosity' or 'pyramidal process.' This is the thickest and strongest part of the whole bone, and its use is to fit into and fill up the 'notch' which is left between the pterygoid plates of the sphenoid. For this purpose its posterior aspect presents a groove which completes the pterygoid fossa, and gives origin to a part of the 'pterygoideus internus.' The groove is bounded by two rough surfaces, which diverge from each other like the letter V reversed, in order to fit into the borders of the notch itself. (Plate XIII. fig. 2.) The anterior aspect of the tuberosity presents a very rugged surface, which articulates with the tuberosity of the superior maxillary bone. Behind this rough surface is a smooth portion continuous with the plane of the external pterygoid plate; this smooth part gives origin to some of

the fibres of the external pterygoid muscle. The inferior aspect has nothing remarkable on it, except the orifices of one or two canals large enough to admit a pin. They are the 'accessory palatine canals,' and transmit the external and the small palatine nerves to the soft palate.

Turning now our attention to the upper part of the palate bone, we observe that at the top of the vertical plate there are two processes. One is called the 'orbital,' because it fills up a little corner at the back part of the orbit; the other is called the 'sphenoidal,' because it fits under the body of the sphenoid bone. These processes are separated by a deep notch, which forms the greater part of the 'spheno-palatine foramen.'

ORBITAL PRO- The 'orbital process' springs from the top of
CESS. the bone by a narrow 'neck,' and is hollow in its interior, so that it forms a cell. The cell contains air, admitted through one of the posterior ethmoidal cells. This little cell has *five* surfaces, each varying in extent, and looking in different directions. If you hold the bone before you, precisely as it is in your own person, and remember that it is interposed between the maxillary in front and the sphenoid behind, you will have no difficulty in recognising the direction of the surfaces to be as follows (see Plate XVII. fig. 2):—the *superior* looks into the orbit and contributes to form its floor; the *external* looks into the zygomatic fossa (or, more strictly speaking, into the spheno-maxillary fossa); the *posterior* is connected with the body of the sphenoid; the *internal* with the ethmoid; and the *anterior* with the superior maxillary bone. Thus, then, we have a superior or orbital surface, an external or zygomatic, a posterior or sphenoidal, an internal or ethmoidal, and an anterior or maxillary: of these five, two only are free, namely, the orbital and the zygomatic—the other three are attached to the respective bones with which they are contiguous. Plate XXVI. shows the little corner at the inner and back part of the orbit, which is filled up by the palate bone, and also the relative position of the bones with which the orbital process is connected. It likewise shows that the 'zygomatic surface' forms that part of the floor of the spheno-maxillary fossa which lies above the spheno-palatine foramen.



SPHENOIDAL
PROCESS.

The 'sphenoidal process' is a thin plate of bone, which arches inwards beneath the body of the sphenoid, and forms part of the roof of the nasal fossa. As it is generally broken in the separate bone, one can see it best in the perfect skull. (Plate XXIV.). The arch which it forms has three surfaces,—an upper or convex surface, which closes in the pterygo-palatine canal; an under or concave surface, which we see in looking into the nasal fossa; and, lastly, an outer, which we see in looking at the bottom of the sphenomaxillary fossa.

SPHENO-PALATINE
FORAMEN.

Respecting the 'sphenopalatine foramen,' we need, for the present, merely observe, that it is an opening which leads from the sphenomaxillary fossa into the cavity of the nose, in order to transmit the nasal or sphenopalatine branch of the internal maxillary artery and nasal branches of the sphenopalatine (Meckel's) ganglion. (Plate XXVI.)

CONNECTIONS.

The palate bone articulates with six bones,—namely, its fellow, the sphenoid, ethmoid, and inferior spongy bones, the vomer, and the superior maxilla.

DEVELOPMENT.

It is developed from a single centre of ossification, which appears at the angle of the horizontal and vertical portions, about the middle of the second month.

INFERIOR SPONGY OR TURBINATED BONE.

(PLATE XIX. figs. 1 and 3.)

In each nasal cavity there are three spongy or turbinated bones—an upper, a middle, and a lower. The upper and middle form part of the ethmoid bone, and have been already described, p. 88. We have now to examine the lower one.

ITS POSITION
AND USE.

This thin plate of bone is well called 'spongy,' from its appearance, and 'turbinated,' from its curved form. By referring to Plate XX. fig. 2, you see it *in situ*, and observe how much longer it is than either of the others.

Its internal surface, forming the convex part of the roll, looks towards the septum of the nose; its external surface forms the concave part, and bounds the inferior meatus of the nose. Both surfaces are covered with little ridges and furrows, and more or less horizontal canals, for the lodgment of numerous plexuses of arteries, but chiefly of veins. This quite accords with the purpose served by the bone, namely, to afford an additional extent of surface for warming the air on its passage into the lungs. It has nothing to do with the sense of smell. The olfactory nerves cannot be traced lower than the middle spongy bone.

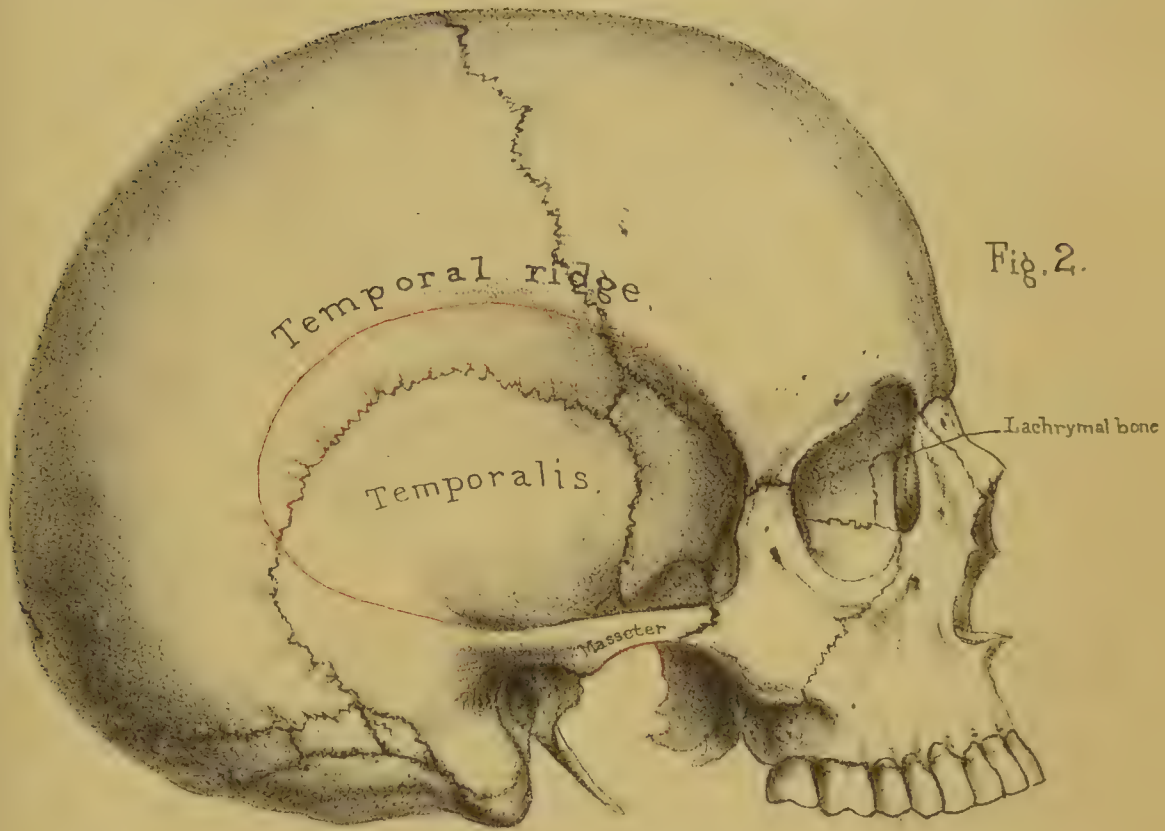
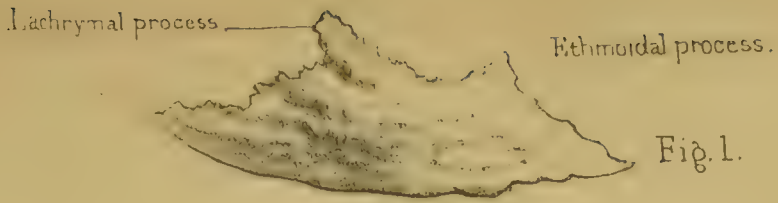
CONNECTIONS.

By its upper edge it is attached along the outer wall of the nose to four bones as follow:—Beginning from the front, we find it attached, 1, to a ridge along the nasal process of the superior maxilla; 2, by means of a little ‘tongue’ (‘lachrymal process’) to just such another ‘tongue’ of the lachrymal; it is this part of the bone which completes the nasal duct; 3, to the orifice of the antrum by means of a triangular plate termed the ‘maxillary process’ (Plate XIX. fig. 3), which turns down like a dog’s ear, and helps to narrow the lower part of the orifice of the antrum; 4, to the unciform plate of the ethmoid by means of a little tongue, called the ‘ethmoidal process’; 5, and lastly, to a ridge along the vertical plate of the palate bone. Notwithstanding these numerous connections, the bone is by no means strongly fixed in its position: in the dry skull it often falls out; and in the operation of extracting a polypus from the nose, it is quite possible to pull out part of the bone or even the entire bone with the polypus.

Its lower edge is free, and generally about half an inch from the floor of the nose, so that there is just room enough to introduce the tube of a stomach pump through the nose.

DEVELOPMENT.

The bone has one independent centre of ossification, which appears about the fifth month of foetal life.



Inferior Spongy bone, outer surface.



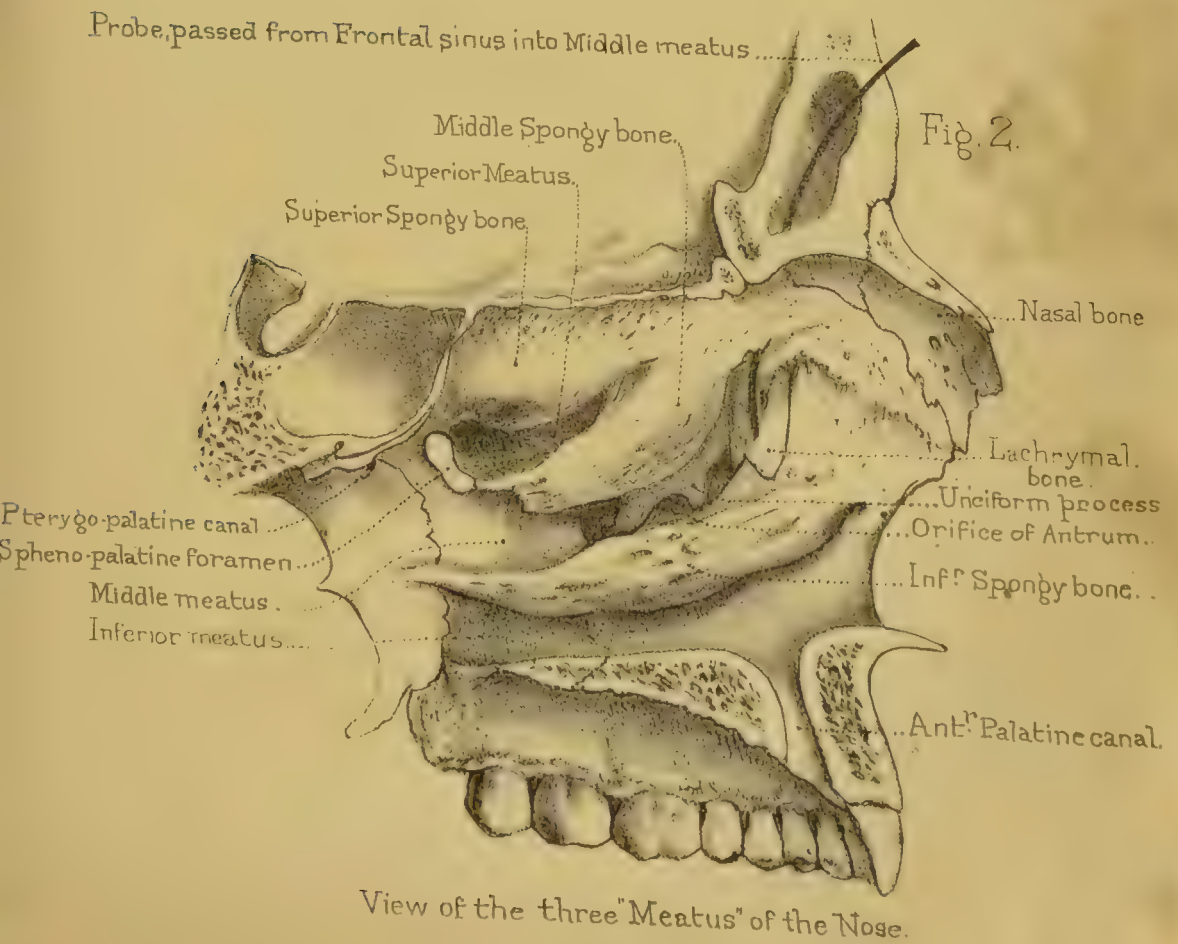
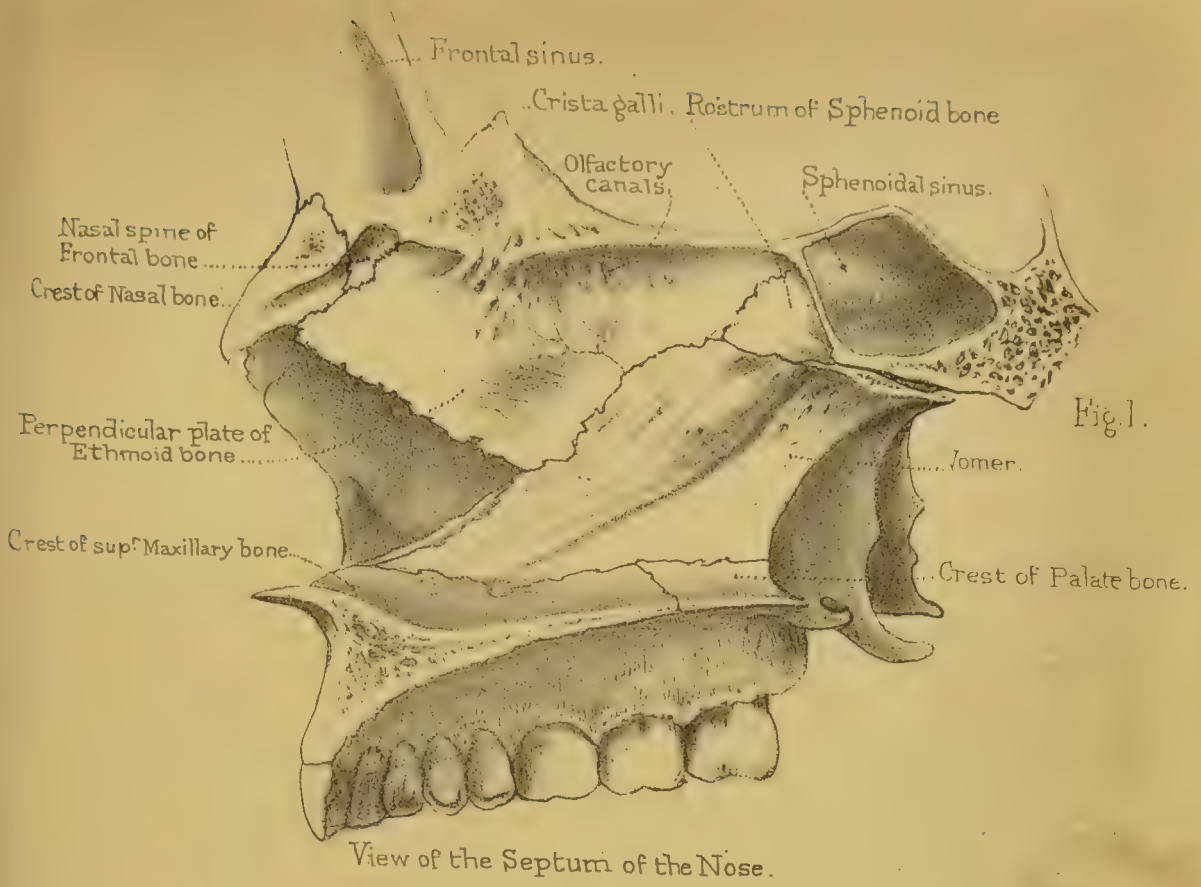
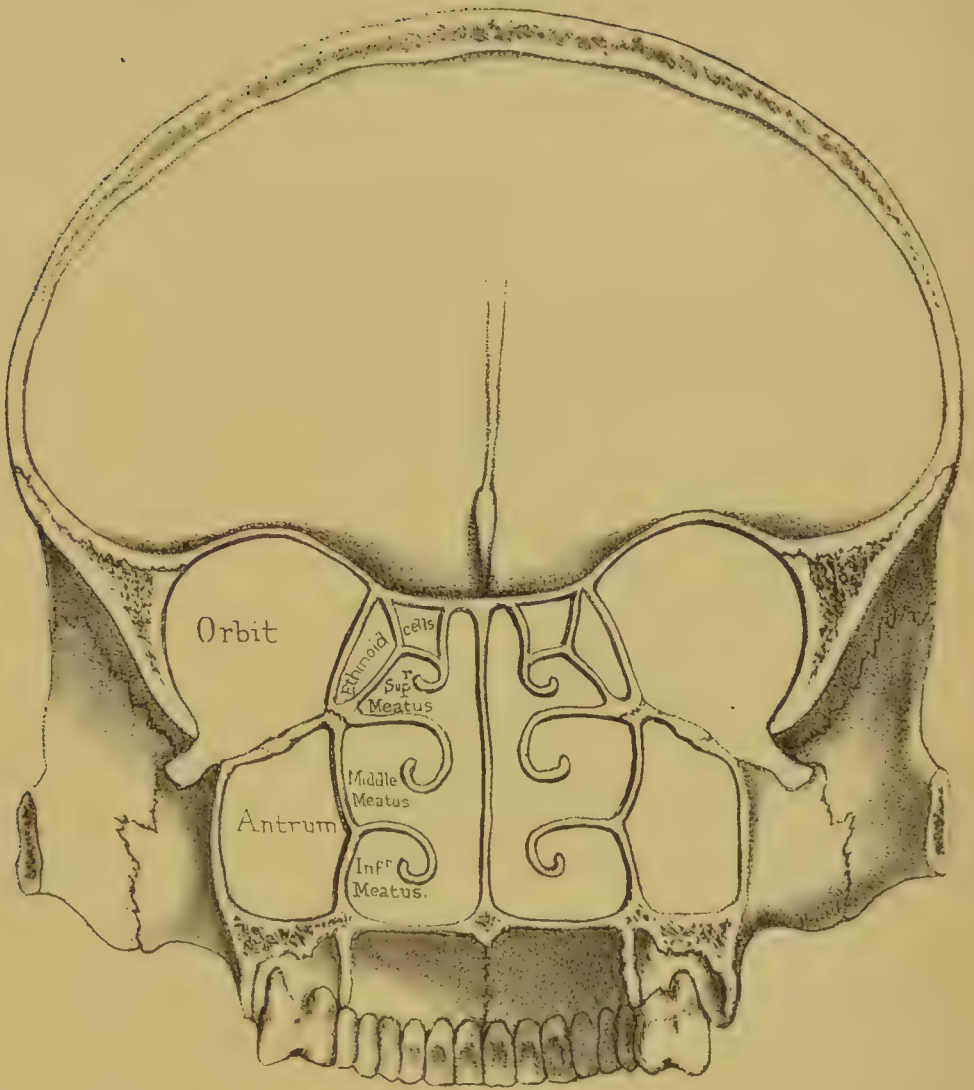


Fig.1.



Section showing the Meatus of the Nose.

Fig.2.



..... Nasal bone.

..... Nasal process of the upper Jaw.

Nasal spine of the Frontal bone

Perpendicular plate of Ethmoid bone.

Section showing the Nasal arch.

THE VOMER.

(PLATE XVIII. fig. 1.)

The 'vomer' is so named from its resemblance to a ploughshare. It is a thin and delicate plate, situated perpendicularly in the middle line, and, together with the perpendicular plate of the ethmoid bone, forms the bony septum of the nose. (Plate XX. fig. 1.)

Thin as it is, the vomer consists of two plates, united in the middle, but separated above, where they become stronger, diverge from each other, and form a deep fissure which receives the 'rostrum' of the sphenoid. The diverging edges of the fissure, called the 'wings,' fit into the little furrows beneath the 'vaginal processes' of the sphenoid. (Plate XIV.) Concerning the other connections of the vomer, we have to observe that the two plates of which the bone is composed separate from each other at every edge of it; and as the vomer receives the other bones into its grooves, so it is locked in on all sides.

CONNECTIONS. The vomer is connected with six bones.

Below, it articulates with the crest of the maxillary and palate bones; in front, with the perpendicular plate of the ethmoid, and the median cartilage of the nose; behind, its edge is sharp and free, and, in the perfect skull, is seen as the septum between the posterior openings of the nasal fossæ.

Both surfaces of the vomer are marked by grooves for blood-vessels and nerves: but the only groove deserving notice is that which descends obliquely and transmits the 'naso-palatine nerve.'

It is necessary to know that the direction of the vomer is not, in all persons, perpendicular. In 100 skulls, I find the vomer perpendicular only in 24. There are instances in which it projects more or less into one side of the nose; and such an unusual projection, when covered by its vascular and swollen mucous membrane, might easily be mistaken for a polypus. Such mistakes are alluded to in surgical works.*

* Jarjavay, 'Anatomic Chir.' t. ii. p. 61.

DEVELOPMENT.

The vomer is developed from one centre of ossification, which begins about the eighth week, at the upper part, and proceeds along each lateral plate.

THE INFERIOR MAXILLARY BONE.

(PLATE XXII.)

For convenience of description we divide the lower jaw into the arched part in front, called the 'body' of the jaw, and the part behind, called the 'ramus,' which ascends at nearly a right angle. At the top of each ramus we observe the 'condyle' or articular surface, the 'coronoid' process for the insertion of the temporal muscle, and the 'sigmoid notch.' Let us examine what is to be seen, first, on the convex surface of the 'body;' secondly, on the concave surface; and, lastly, on each surface of the ramus.

BODY AND SYMPHYSIS.

The convex part of the body presents, exactly in the centre, a slight ridge, termed the 'symphysis.' This is the strongest part of the bone, and indicates where the two halves of the bone grew together.* Observe that its direction is vertical: this is one of the characteristics of man; he alone has a chin. The 'symphysis' terminates, below, in a triangular 'mental process,' more or less marked in different individuals. On each side of the symphysis is a slight depression, termed the 'mental fossa,' which gives origin to the 'levator menti.' More externally, and generally in a line with the first pre-molar tooth, is the 'foramen mentale,'† which transmits the 'mental branch' of the inferior dental nerve and artery. From the lower part of the symphysis we trace the beginning of the 'external oblique line' or ridge, which curves backwards towards the root of the coronoid process. This line gives origin to the 'depressor labii inferioris'

* In serpents the lateral halves of the lower jaw are not united by bone, but held together by an elastic ligament, which permits the two halves of the jaw to be separated from each other sideways, to a considerable extent. This is one of the many provisions by which a boa is enabled to swallow its prey, though larger than its own body.

† The position of the 'foramen mentale' is by no means constant.

See also the next page, relating to the same bone.
The opposite 1st Bicuspis.
The 2nd Bicuspis from an examination of 3 views.

and ‘depressor anguli oris.’ A little below both these, is the insertion of the ‘Platysma-myoides’ of the neck. Along the alveolar border adjacent to the three molar teeth is one origin of the ‘buccinator.’

FOUR TUBERCLES. On the concave or hinder surface of the body (fig. 2), we observe, at the symphysis, four small tubercles, i.e. two on each side, one above the other; the upper give origin to the ‘genio-hyoglossi:’ the lower, to the ‘genio-hyoidei.’* Beneath these is a well-marked depression on each side, for the insertion of the ‘digastricus.’ On this surface also we see another oblique line, beginning faintly near the symphysis, and becoming gradually more prominent as it ascends backwards below the last molar tooth. It is called the ‘mylo-hyoid ridge,’ because it gives origin to the ‘mylo-hyoideus.’ Behind and a little above this ridge, near the last molar tooth, is the origin of part of the ‘superior constrictor’ of the pharynx. Below this ridge is a slight depression, indicating the place where the sub-maxillary salivary gland lies. Above the ridge is the place for the sub-lingual gland; but this is not well marked.

MEANING OF OBLIQUE LINES. The oblique lines or ridges alluded to on the two surfaces of the body denote something more than mere muscular impressions. They indicate the limit between the ‘alveolar’ part which contains the teeth, and the lower or ‘basilar’ part of the jaw. We make these distinctions because these parts come and go at different periods of life. In infancy we have only the alveolar part; towards puberty the basilar part slowly grows to perfection; in old age when the teeth fall out, and their sockets are absorbed, the basilar part alone remains, and the chin gradually approximates the nose. The absorption of the sockets (alveoli), which is natural in old persons, becomes disease when it happens in middle life, and produces premature age in the jaws. This absorption is apt to arise from long salivation, scurvy, or purpura; frequently it is hereditary.

TEETH IN THE LOWER JAW. The teeth in the lower jaw correspond in number (eight on each side) with those in the upper, but differ from them in one or two particulars:—1. The lower

* These four tubercles in some instances are confluent, and appear as one.

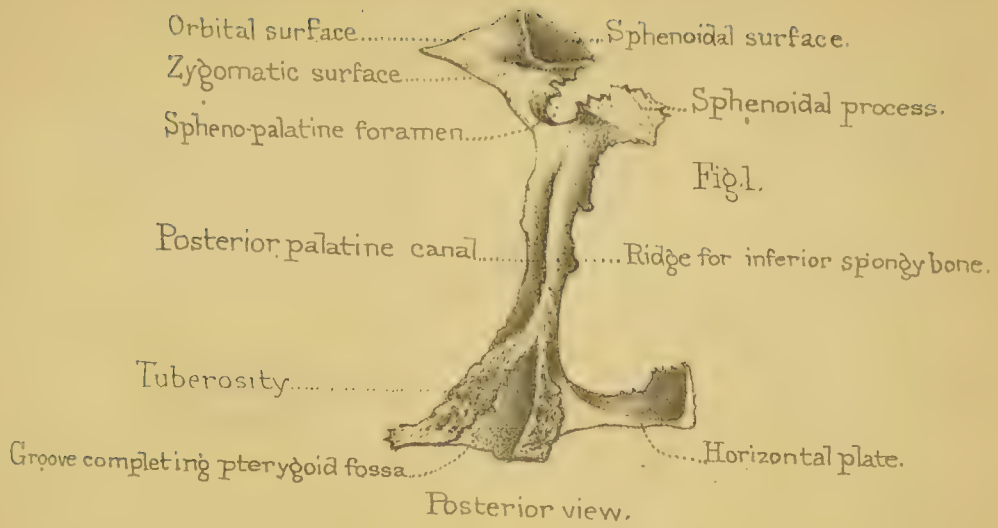
molars have only two fangs, an anterior and posterior, while the upper molars have three; 2. When the mouth is closed the teeth of the lower jaw shut behind those of the upper jaw which form a larger arch; 3. The external tubercles or cusps of the teeth of the lower jaw fit into the hollows between the external and internal cusps of the teeth of the upper jaw; by which arrangement we are enabled to use the entire surface of the opposing teeth in grinding the food. When the jaws are closed, each tooth in one jaw is opposed by two in the opposite jaw; one good result of this is, that when we lose a tooth, the corresponding tooth in the other jaw being still more or less opposed, is still of service in mastication.

RAMUS.

The ramus of the jaw mounts up from the body nearly at a right angle in adult age, when the upper and lower jaws are kept well apart behind by the molar teeth. But in infancy, before the development of the molars, and in age when they have decayed, the 'angle' of the jaw becomes obtuse. Excluding its outstanding processes, the ramus is nearly square. Nearly the whole of its outer surface gives insertion to the powerful 'masseter,' which closes the jaw (fig. 1). On its inner surface (fig. 2) we observe the 'dental foramen,' or the orifice of the canal for the transmission of the inferior dental nerve and artery. The inner margin of the orifice is raised into a short 'spine' for the attachment of the internal lateral ligament of the jaw. Leading down from the orifice is the 'mylo-hyoid groove,' which contains the mylo-hyoidean vessels and nerve. Below the groove is the rough surface for the insertion of the 'pterygoideus internus.' Observe that strong muscles are inserted into the *angle* of the jaw both on the outer and on the inner surface; and that for this reason fractures through this part of the bone sometimes escape detection.

CONDYLE.

The 'condyle' projects from the upper and back part of the ramus to form the joint of the jaw, and fits into the glenoid cavity of the temporal bone. It is oblong in form, and convex both from without inwards and from before backwards. The long axis is directed horizontally inwards and slightly backwards, so that, if prolonged, the axis of the two condyles would meet near the front of the 'foramen magnum.'



PALATE BONE.

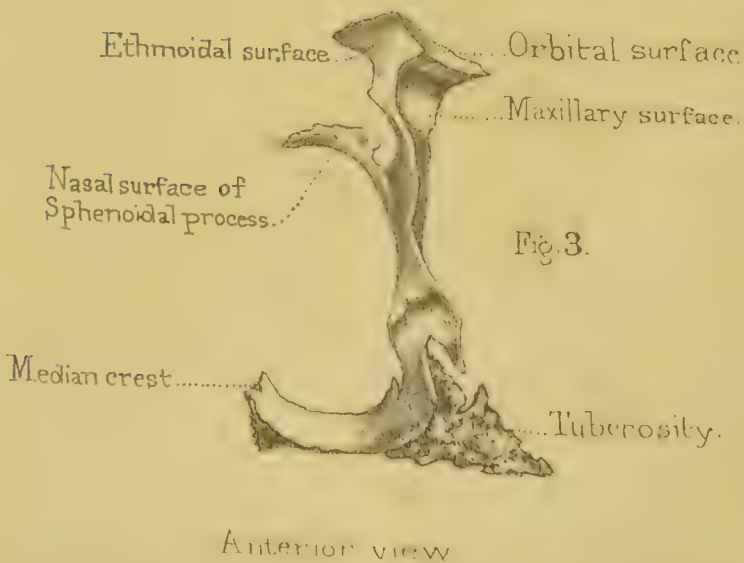
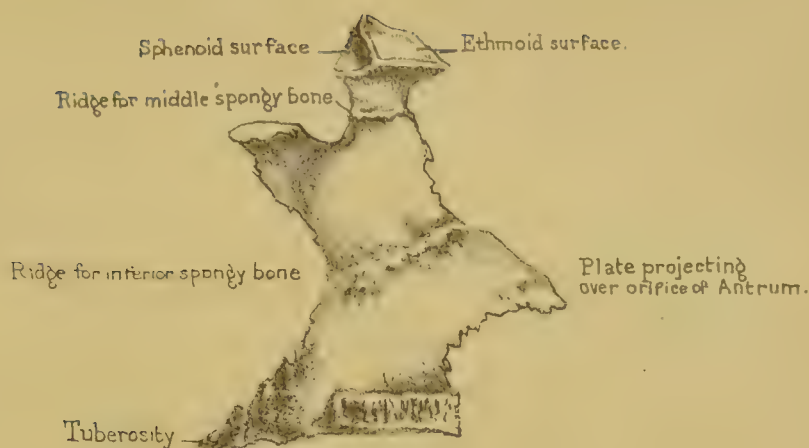




Fig. 1.



INTERNAL VIEW OF PALATE BONE.

Fig. 2.

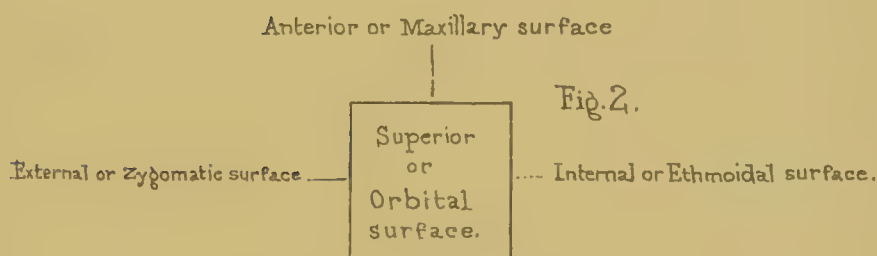


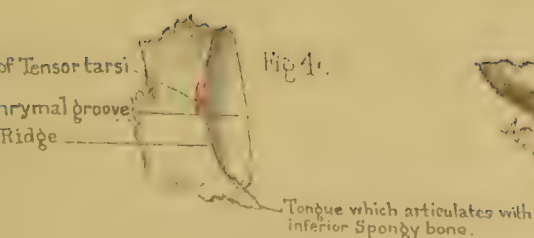
Diagram of the orbital process of the Palate bone.

Fig. 3.



MALAR BONE.

Fig. 4.



LACHRYMAL BONE.

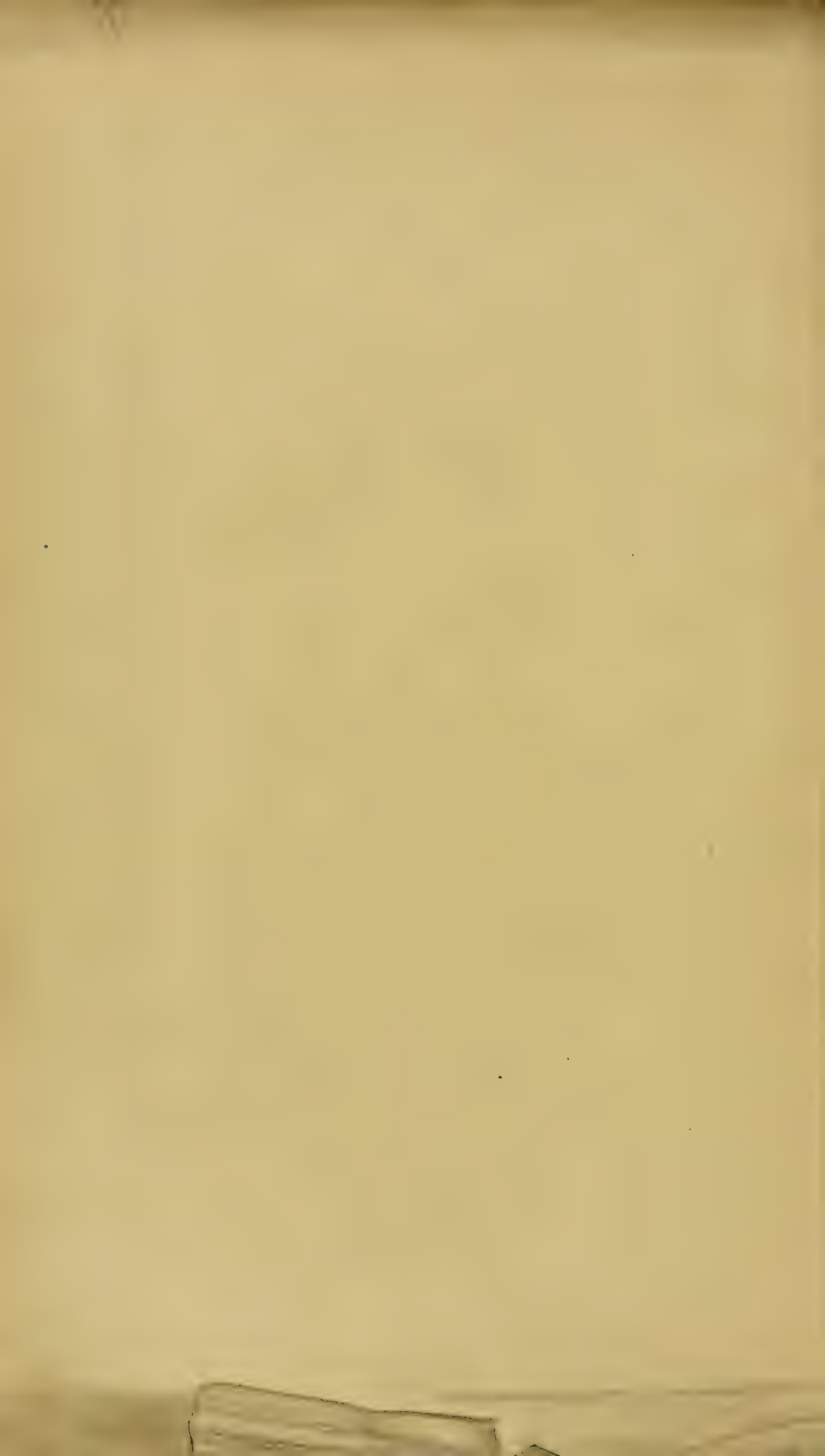


Fig. 1

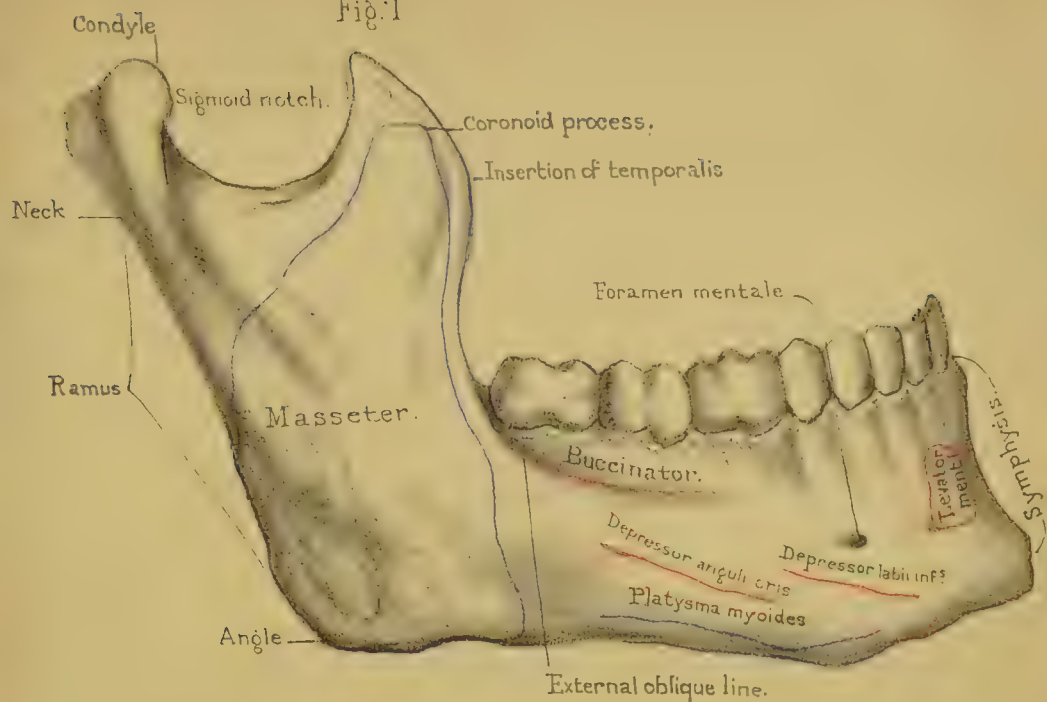
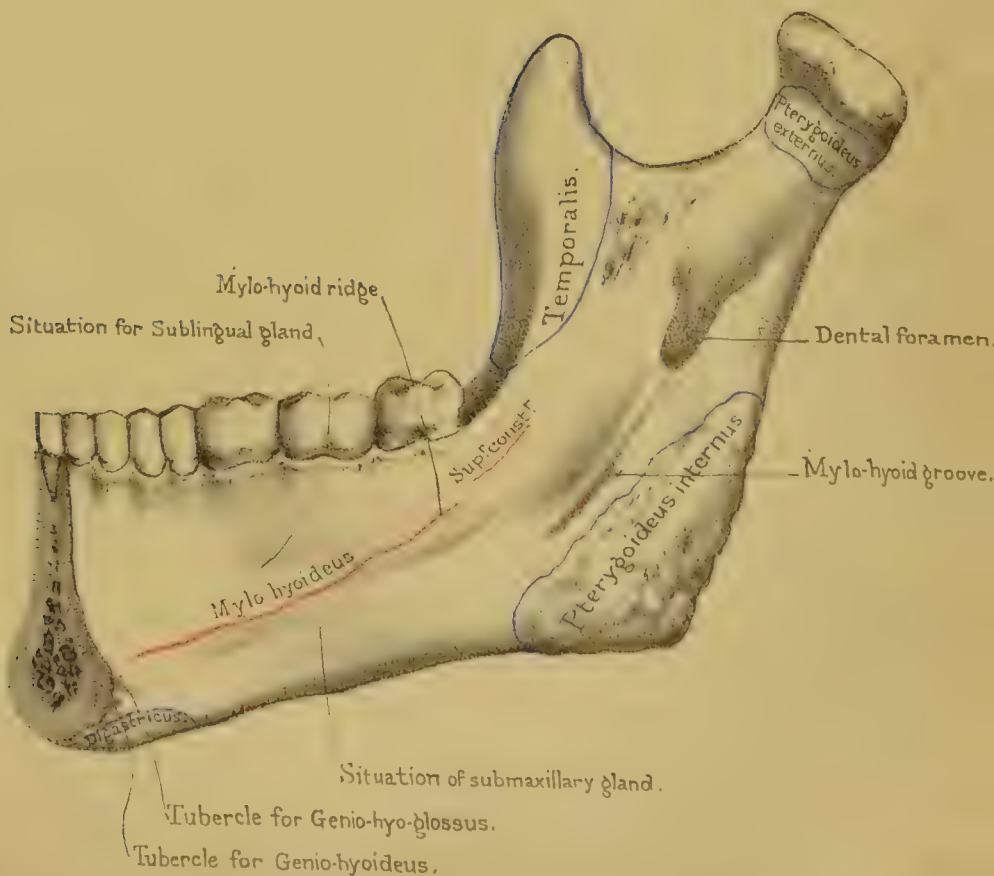


Fig. 2



Just outside the condyle is a 'tubercle' for the attachment of the external lateral ligament. The condyle is supported on a contracted part termed the 'neck' of the jaw. This neck is flattened in the same direction as the condyle, and is slightly excavated in front for the insertion of the 'pterygoideus externus.'

CONDYLES,
WHY PLACED
OBLIQUELY?

Why are the condyles of the jaw placed obliquely? The answer is, to facilitate the oblique rotatory movements necessary for the mastication of our food. In masticating, we can readily feel that one condyle advances towards the anterior margin of the glenoid cavity, while the other recedes towards the posterior margin.

OBSERVATIONS ON
THE JOINT OF THE
JAW IN ANIMALS.

The joint of the lower jaw in man is a much more beautiful mechanism than it appears at first sight. Fully to appreciate it, we must look a little at the form of the joint in animals. In animals this joint varies according to the structure of their teeth and the food they eat.

There are three principal types of it: the *carnivorous*, the *ruminant*, and the *rodent*. The *carnivorous* type is a simple transverse hinge: this form is well seen in the badger, in which animal the condyle of the jaw is mechanically locked in its socket. It is shown in fig. 18, where G represents the shape of the glenoid cavity, and C the shape of the condyle which fits into it. The *ruminant* type presents a socket and a condyle nearly flat, so as to admit of the lateral movement necessary for grinding the food. This form is seen in fig. 19, which is taken from the sheep. In the *rodent* type there is a longitudinal groove in the temporal bone in which the condyle plays from before backwards like a plane. Fig. 20 shows the corresponding surfaces of the glenoid cavity (G), and the condyle (C), in the capybara.

FIG. 18.

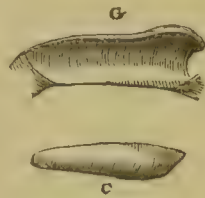


FIG. 19.



FIG. 20.



Now the joint of the lower jaw in man partakes, more or less, of the nature of these three types: that is to say, we can move our jaw, in the vertical direction, from side to side,

and from before backwards. The teeth of man are likewise intermediate in structure between those of carnivorous and those of ruminant animals. Man, therefore, is said to be omnivorous.*

CORONOID PROCESS. The 'coronoid' process is a triangular, lofty plate of bone, which ascends beneath the zygomatic arch in order to increase the leverage of the temporal muscle which closes the jaw. Observe that the insertion of this muscle occupies the inner surface, the apex, and front border of the process down to the last molar tooth: the greater part of the outer surface of the process is occupied by the masseter. Respecting the 'sigmoid notch' there is nothing to be said, except that it transmits the 'masseteric' nerve and artery.

The walls of the lower jaw, particularly at the basilar part, are exceedingly compact and tough. In operations for removal of this part of the bone, it is necessary to use the saw freely, before the bone forceps can be of any service. The interior assumes the form of 'diploe,' and is traversed by the 'inferior dental canal,' which carries the vessels and nerves to the teeth. We have seen that the canal begins on the inner side of the ramus; if it be traced out by cutting away the inner wall, we find that it curves forwards, beneath the sockets of the teeth, and, towards the front, divides into two, of which one ends at the 'foramen mentale,' the other, much diminished in size, runs on through the diploe nearly to the symphysis, in order to convey vessels and nerves to the canine and incisor teeth.

DEVELOPMENT. The lower jaw has two centres of ossification, which appear about the sixth week; one for each lateral half. Their junction at the symphysis takes place about the close of the first year after birth. In the lower animals the symphysial suture often remains throughout life.†

* At least man is adapted, by his dentition, to eat animal or vegetable food. But the presence of grinding, tearing, and cutting teeth, equally developed, in the jaws of any animal, is no proof that he is omnivorous. Monkeys have large canines, yet live on vegetables; all bats possess well-formed incisors, canines, and molars, yet some are purely frugivorous, whilst the British species live entirely on insects.

† For a lucid and elaborate account of the development of the jaws and the teeth see 'Manual of Dental Anatomy,' by C. S. Tomes, M.A., 1876.

THE SKULL AS A WHOLE.

THE examination of the Skull as a whole is easy and intelligible, provided the individual bones have been carefully studied.

COURSE OF THE SUTURES. First of all we must learn the course of the sutures. This is of practical moment—1, because it enables us to say with precision in what direction the head of the child is presenting during labour; 2, because in injuries of the skull we must not commit the error of mistaking a suture for a fracture; * 3, because it is desirable not to trephine in the course of the sutures.

CORONAL SUTURE. The ‘coronal suture’ (Plate XXVII.) (fronto-parietal) connects the frontal with the parietal bones. It extends transversely across the top of the skull, from the great wing of the sphenoid on one side to the other. Concerning the construction of this suture, we must remember that in the middle the frontal overlaps the parietal bones, whereas at the sides the parietals overlap the frontal: a provision which manifestly tends to lock the bones together.

SAGITTAL SUTURE. The ‘sagittal suture’ (inter-parietal) connects the two parietal bones. It runs directly backwards, in the middle line, from the frontal to the occipital bone. This suture is very much serrated, except near the parietal foramina, where it is always much straighter than elsewhere.†

* Skilful as he was, Hippocrates once mistook a natural suture of the skull for a fracture, and was afterwards so ingenuous as to leave his mistake on record. On this, Celsus observes: ‘A suturis se deceptum esse Hippocrates memoriæ prodidit, more scilicet magnorum virorum, et fiduciam magnarum rerum habentium. Nam levia ingenia, quia nihil habent, nihil sibi detrahunt: magno ingenio, multaque nihilominus habituro, convenit etiam simplex veri erroris confessio; præcipuèque in eo ministerio quod utilitatis causâ posteris traditur, ne qui decipiantur eadem ratione, quâ quis antè deceptus est.’ (Liber viii. cap. iv.)

† Broca, ‘Ostéologie du Crâne,’ 1875.

FRONTAL
SUTURE.

The 'frontal suture' is formed by the union of the two halves of the frontal bone. It runs down the middle of the forehead, from the sagittal suture to the root of the nose. It always exists in infancy and childhood, but is generally obliterated in the adult (p. 68).

LAMBDOID
SUTURE.

The 'lambdoid suture' (Greek letter Λ) (occipito-parietal) unites the two parietals to the occipital bone.

OCCIPITO-MAS-
TOID SUTURE.

The 'occipito-mastoid suture,'* apparently a continuation of the lambdoid, connects the occipital with the mastoid portion of the temporal bone.

MASTO-PARIE-
TAL SUTURE.

The mastoid part of the temporal is connected to the posterior inferior angle of the parietal bone by the 'masto-parietal suture.'

SQUAMOUS
SUTURE.

The squamous part of the temporal is connected to the parietal bone by the 'squamous suture' (squamo-parietal); and to the great wing of the sphenoid by the 'squamo-sphenoidal' suture. Concerning these connections, we must observe the great extent to which the squamous bone overlaps the parietal; an adaptation which mainly strengthens the arch of the skull at the sides, and prevents the lateral expansion of the buttresses.

WORMIAN
BONES.

In the mastoid suture more frequently than in any other, we meet with what are termed 'Wormian† bones,' or 'ossa triquetra.' They are like little islands of bone, developed from distinct centres, in the membrane which connects the cranial bones. They vary in number and size. In the Museum of the College of Surgeons there is the hydrocephalic skull of an adult‡ (from the collection of the late Mr. Liston), in which there are upwards of one hundred of these little bones.

* The old anatomists call this the 'additamentum suture lambdoidalis.' This old name, as well as others mentioned in the text, e.g. 'coronal,' 'sagittal,' and 'lambdoid,' are gradually falling into disuse, and giving place to more appropriate terms, derived from the bones connected, as, 'inter-parietal,' 'fronto-parietal,' etc.

† So called after Olaus Wormius, a physician of Copenhagen, to whom the first description of these 'complementary' bones has been assigned, —but erroneously: they were known to Eustachius and Paracelsus.

‡ No. 3489, Pathological Series.

TRANSVERSE
FRONTAL SUTURE.

Of the sutures which connect the bones of the cranium with the face, there is one which deserves notice, as being very comprehensive. It is called the 'transverse frontal suture.' It extends from the external angular process of the frontal bone, from one side to the other, across both orbits and the root of the nose (Plate XVIII.). It connects the frontal with the malar, sphenoid, ethmoid, lachrymal, superior maxillary, and nasal bones. Other short sutures, such as the 'spheno-malar,' 'spheno-parietal,' 'zygomatic,' etc. speak for themselves.

We said that a knowledge of the sutures concerns midwifery. It enables us to say which way the head of the child is presenting. If we feel the meeting of the three sutures at the top of the occipital bone, we know the back of the head presents; if, again, we feel the 'anterior fontanelle,' or lozenge-shaped space where four sutures meet (page 62), we know it is a forehead presentation.

THE SKULL-CAP.

SKULL-CAP,
OUTER SURFACE.

The skull-cap forms a beautiful oval dome for the protection of the brain. We all know the outward form of the head, and that the greatest breadth of it is about the parietal protuberances. In a well-formed European head, if we look at the skull-cap from above (the beginning of the sagittal suture being in the centre of the perspective plane), we see scarcely anything but the smooth expanded vault of the cranium. But in the Negro and the Australian, the narrowness of the temples allows the zygomata to come into view, and in the most 'prognathous' * examples, the incisor teeth appear in front of the frontal sinuses.

FORAMINA.

On the outer surface of the skull-cap are a multitude of minute foramina, which transmit blood-vessels from the pericranium into the substance of the bone. Hence, if this membrane be torn off during life, the bone bleeds through minute pores. We observe on each side of the sagittal suture the 'foramen parietale,' which transmits a vein from the outside into the great longitudinal sinus: sometimes a small artery

* 'Prognathous' signifies, 'with prominent jaws.'

runs with it, and communicates with a branch of the middle meningeal. Along the side of the skull-cap we observe the curved line called the temporal ridge (Plate XIX.). It indicates the attachment of the temporal aponeurosis, and runs along the side of the frontal and parietal bones.

TEMPORAL
RIDGE.

TEMPORAL
FOSSA.

The ridge circumscribes the 'temporal fossa,' which is formed by the frontal, parietal, temporal, sphenoid, and malar bones. The fossa gives origin to the temporal muscle, of which the tendinous rays, converging beneath the zygoma, are inserted into the coronoid process of the lower jaw. The size of the temporal fossa in all animals depends upon the size of the temporal muscle. Hence it is largest in the carnivora. In these animals the fossa occupies the whole side and upper part of the skull, and is increased in extent by bony ridges growing from the frontal, parietal, and occipital bones; so that their enormous temporal muscle almost completely covers the cranium.

SKULL-CAP,
INNER SURFACE.

On the inner surface of the skull-cap we observe —1, the groove in the middle line, which gradually becomes broader as we trace it backwards, for the great longitudinal sinus; 2, on either side of this, especially in old skulls, are a number of irregular excavations, occasioned by the so-called 'Pacchionian bodies,' or 'glands of Pacchioni';* 3, grooves for the ramifications of the 'arteria meningeal media.' The main groove, at first sometimes a complete canal, is seen at the anterior-inferior angle of the parietal bone; from thence we trace its wide-spreading branches over the frontal and parietal bones: one of considerable size often traverses the posterior-inferior angle of the parietal. In fractures of the skull, the arteries running in these grooves are liable to be injured, and thus occasion an effusion of blood between the bone and the dura mater, producing compression of the brain.

THICKNESS OF
THE SKULL-CAP.

The skull-cap differs in thickness in different parts. This is easily ascertained by holding it to the light. As a rule, it is thicker in parts which are most exposed

* These bodies are developed from the 'arachnoid' or serous membrane investing the brain, beneath the 'dura mater,' which they perforate, and thus come to press immediately on the bony vault of the skull. *Vide* Quain's 'Anatomy,' vol. ii., p. 576. 8th edition.

to injury,—as at the frontal, parietal, and occipital eminences, also along the course of the longitudinal sinus. It is thinnest in the temporal region. If one were asked, what is *about* the ordinary thickness of an adult skull, one would say, about one-fifth of an inch. But then it would be right to add, that it varies very much at different periods of life. In the anatomical museum at Pavia there is the skull-cap of a child, in which a hole was pecked by the beak of an angry cock. Whoever is in the habit of making post-mortem examinations soon observes how much skulls vary in thickness, even in persons of the same age, and this without any obvious reason. Generally speaking, any cause which produces a chronic congestion of the vessels of the head,—such as habits of intemperance,—will increase the thickness of the skull. For the same reason constant exposure to the action of the sun will thicken and indurate the skull-cap. The observation of Herodotus* is probably correct, when he says that ‘the Egyptians have thick skulls because they expose their shorn heads to the heat of the sun; whereas the Persians have thin and soft skulls, because they cover them with turbans from infancy.’ A severe blow may thicken the skull. The late Mr. Quekett had in his possession part of a skull-cap nearly an inch in thickness. It belonged to a gentleman who received a blow on his head some years before his death. He recovered perfectly, to all appearance, from the effects of the injury. By-and-by, however, his head began to grow larger; but this, strange to say, was first discovered by his latter, who found it necessary from time to time to give him a larger hat.

In very old persons, the skull-cap, owing to the absorption of the diploe, becomes in some parts not thicker than a shilling. Not only the skull, but all the bones become much lighter in old age. Soemmerring says the skull of a centenarian is two-fifths lighter than in middle age.

CEREBRAL IMPRESSIONS.

The inner surface of the skull-cap is marked by the cerebral convolutions, so that it takes, to a certain extent, an impression of the brain. But it cannot be said with truth that a particular impression on the inner surface has a corresponding bump outside. A glance at any skull-cap is

* ‘Thalia,’ xii.

sufficient to prove this. The depressions occasioned by the convolutions take place at the expense of the diploe; and even the external bumps are often caused by a mere thickening of the outer table. On the other hand, it holds good, as a general rule, that the external form and dimensions of the cranium may be taken as a *general* expression of the corresponding lobe of the brain, whether in the frontal, the parietal, or the occipital region. The general characters of the brain, then, may be ascertained by external examination, but not the individual detail.

VEINS OF THE DIPLOE.

The diploe of the skull-cap is traversed by numerous venous canals. These, as shown in the following cut (fig. 21), are of considerable size, and are best displayed by filing off the outer table. Their course is by no means so regular as they are commonly drawn; but, in a general way, we may speak of the frontal, temporal, and occipital 'diploic' veins. The two former discharge their blood into the veins on the outside of the cranium; the latter generally open into the lateral sinus. After injuries of the head, these veins are liable to in-

flammation, and thus give rise to pus in the diploe, which may produce all the symptoms and disastrous results of pyæmia. Hence the occasional occurrence of visceral abscesses, especially hepatic, after injuries of the head,—a circumstance which had not escaped the notice of the old surgeons.

FIG. 21.



VENOUS CANALS IN THE DIPLOE.

BASE OF THE SKULL AS SEEN FROM WITHIN.

By referring to Plate XXIII. it is seen that the base of the skull presents, on each side, three fossæ,—an anterior, a middle, and a posterior,—respectively corresponding to the anterior and middle lobes of the cerebrum, and to the cerebellum.* These several fossæ are marked by the cerebral convolutions, just as much as the skull-cap; but phrenologists take no notice of *these* convolutions, and have omitted to assign any office to them. All their ‘organs’ are placed at the top and sides of the brain;—why are there none at the base?

ANTERIOR
FOSSA OF THE
CRANIUM.

The anterior fossa of the cranium is formed by the orbital plates of the frontal, the cribriform plate of the ethmoid, with the front part of the body and the lesser wings of the sphenoid. The points to be noticed in this fossa are as follows: 1. The ‘foramen cœcum,’ which, if pervious, generally transmits a vein from the nose into the longitudinal sinus. 2. The groove for the ‘anterior meningeal artery,’ one of the secondary branches of the ophthalmic. 3. The ‘crista galli,’ which gives attachment to the falx cerebri. 4. The slit for the ‘nasal nerve,’ a branch of the first division of the fifth nerve. 5. The ‘olfactory groove,’ perforated by foramina, which give passage to the filaments of the olfactory lobes. 6. The ‘anterior orbital foramen’ on the outer side of the olfactory groove, for the transmission of the nasal nerve and anterior ethmoidal vessels. 7. The ‘posterior orbital foramen,’ at the hinder extremity of the olfactory groove, immediately in front of the body of the sphenoid; it transmits the posterior ethmoidal vessels. 8. The ‘foramen opticum,’ which transmits the optic nerve and ophthalmic artery. 9. The ‘olivary process,’ which supports the commissure of the optic nerves. 10. The ‘anterior clinoid process,’ which gives attachment to the tentorium cerebelli.

MIDDLE FOSSA
OF THE CRANIUM.

The middle fossa of the cranium supports the middle cerebral lobe, and is formed by the great

* The posterior lobe of the cerebrum rests upon the ‘tentorium cerebelli,’ and not upon bone.

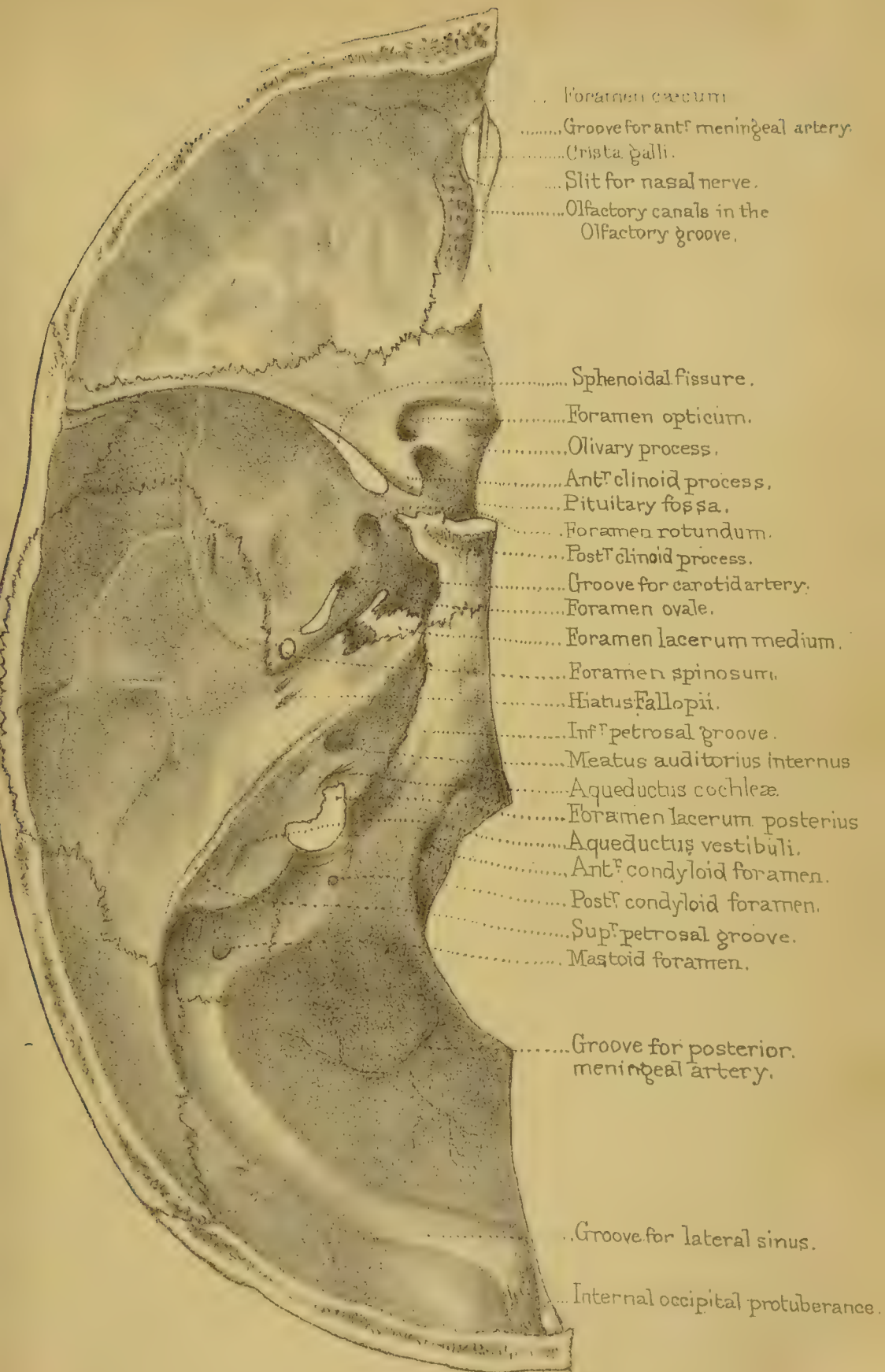
wing of the sphenoid, the squamous and petrous portions of the temporal bone. The points to be noticed in this fossa are as follows:—1. ‘The sphenoidal fissure’ between the wings of the sphenoid leads to the orbit, and transmits the 3rd, the 4th, the first division of the 5th, and the 6th nerves, also filaments of the sympathetic nerve and the ophthalmic vein. 2. The ‘foramen rotundum’ gives passage to the superior maxillary, or second division of the 5th nerve. 3. The ‘foramen ovale’ gives passage to the inferior maxillary, or third division of the 5th nerve, and also to the *arteria meningea parva*.* 4. The ‘foramen spinosum’ gives passage to the *arteria meningea media* and its two veins—the main trunk of this artery grooves the squamous part of the temporal and the anterior-inferior angle of the parietal bone. 5. The ‘foramen lacerum medium’ is blocked up, in the recent state, by fibro-cartilage: through this cartilage the Vidian (great petrosal) nerve enters the skull. The internal carotid artery also passes through it. 6. At the apex of the petrous portion of the temporal bone is the termination of the ‘carotid canal’ through which the carotid artery enters the skull: the artery then winds along the groove on the side of the body of the sphenoid. 7. On the front surface of the petrous portion of the temporal bone is the ‘hiatus Fallopii,’ which transmits the great petrosal nerve, and external to it is the opening of the canal for the lesser petrosal nerve. More posteriorly, on the same surface, we may observe the eminence for the superior semicircular canal. 8. In the centre of the sphenoid is the ‘pituitary fossa,’ for the reception of the pituitary gland. 9. The ‘posterior clinoid process,’ like the anterior, gives attachment to the ‘tentorium† cerebelli,’ a process of the dura mater which supports the posterior lobes of the brain.

POSTERIOR
FOSSA OF THE
CRANIUM.

The posterior fossa is the largest and deepest of the cranial fossæ, and is formed by the occipital bone, the petrous and mastoid parts of the temporal bone. It supports the cerebellum. Proceeding from before backwards, we observe, in the middle line: 1. The

* And sometimes the lesser petrosal nerve.

† This ‘tentorium’ is ossified in the Carnivora and other Mammalia.



‘basilar groove,’ which supports the medulla oblongata and the pons. 2. On each side of this is the groove for the ‘inferior petrosal sinus.’ 3. Along the top of the petrous bone is the groove for the ‘superior petrosal sinus.’ 4. Both these sinuses terminate in the ‘great lateral sinus,’ which is seen grooving, successively, the occipital, posterior-inferior angle of the parietal, mastoid part of the temporal, and, last of all, the jugular process of the occipital bone. It is worth remembering that a line drawn on the outside of the head, from the occipital protuberance to the front border of the mastoid process, corresponds with the lateral sinus.

On the posterior aspect of the petrous part of the temporal bone is—5. The ‘meatus auditorius internus,’ for the facial and auditory branches of the seventh nerve and the little auditory artery. 6. Some distance behind, and rather below the meatus, is the ‘aqueductus vestibuli,’ somewhat concealed by an overhanging ridge of bone. This ‘so-called’ aqueduct transmits, if anything, a small vein from the vestibule of the ear.

Behind the basilar process is—7. The ‘foramen magnum,’ which transmits the spinal cord and its membranes, the vertebral arteries, and the spinal accessory nerves. 8. On each side of the foramen magnum are the ‘condyloid foramina,’ of which the ‘anterior’ transmits the hypoglossal or 9th nerve (motor nerve of the tongue); the ‘posterior,’ a vein from the outside of the skull into the lateral sinus. 9. The ‘mastoid foramen’ also transmits a vein from without into the lateral sinus. 10. Lastly, the ‘foramen lacerum posterius’ transmits the three divisions of the 8th nerve and also the blood from the lateral sinus into the internal jugular vein. The nerves pass through the anterior part of the foramen, which is separated from the posterior by a bony ridge.

BASE OF THE SKULL AS SEEN FROM BELOW.

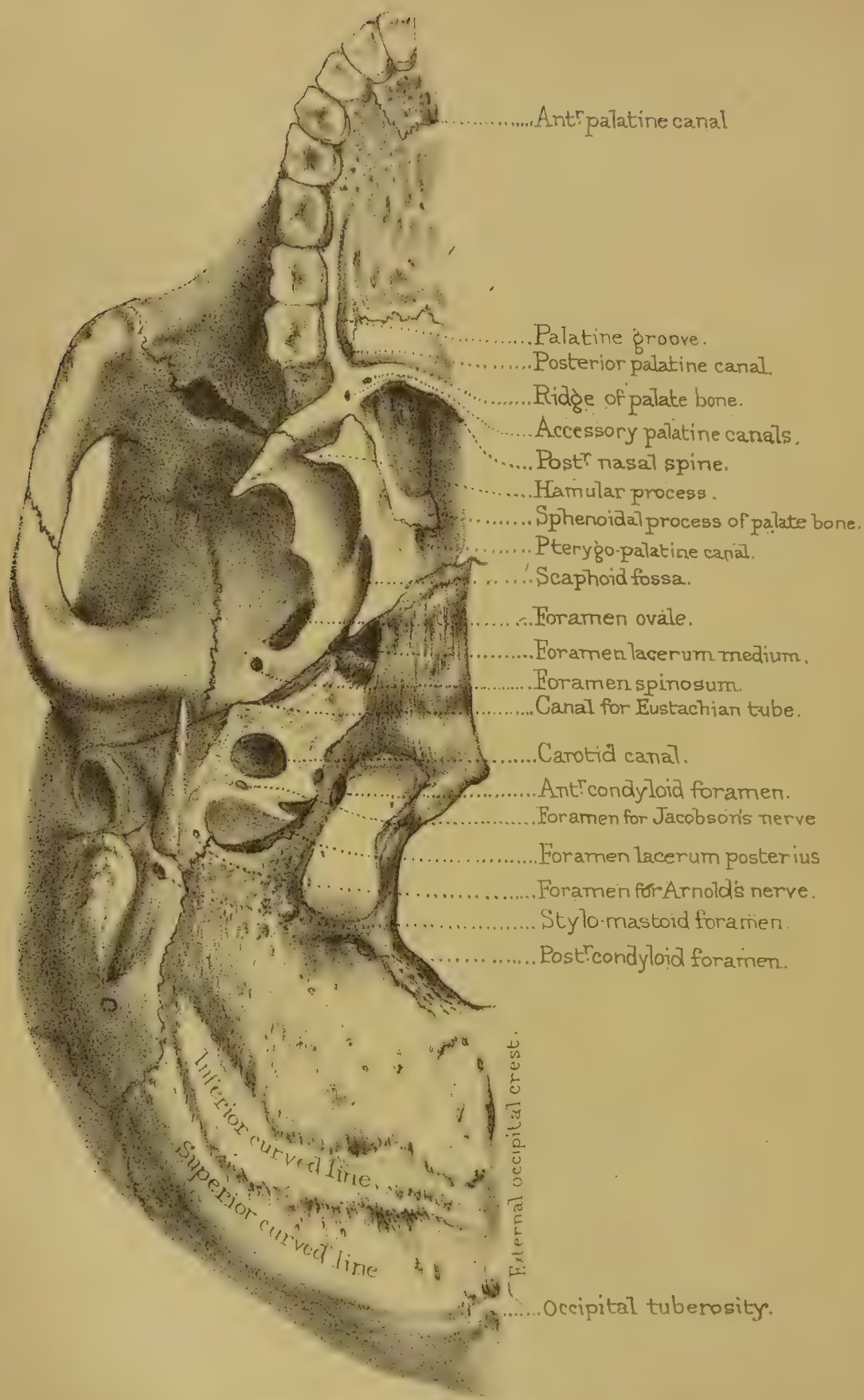
(PLATES XXIV., XXV.)

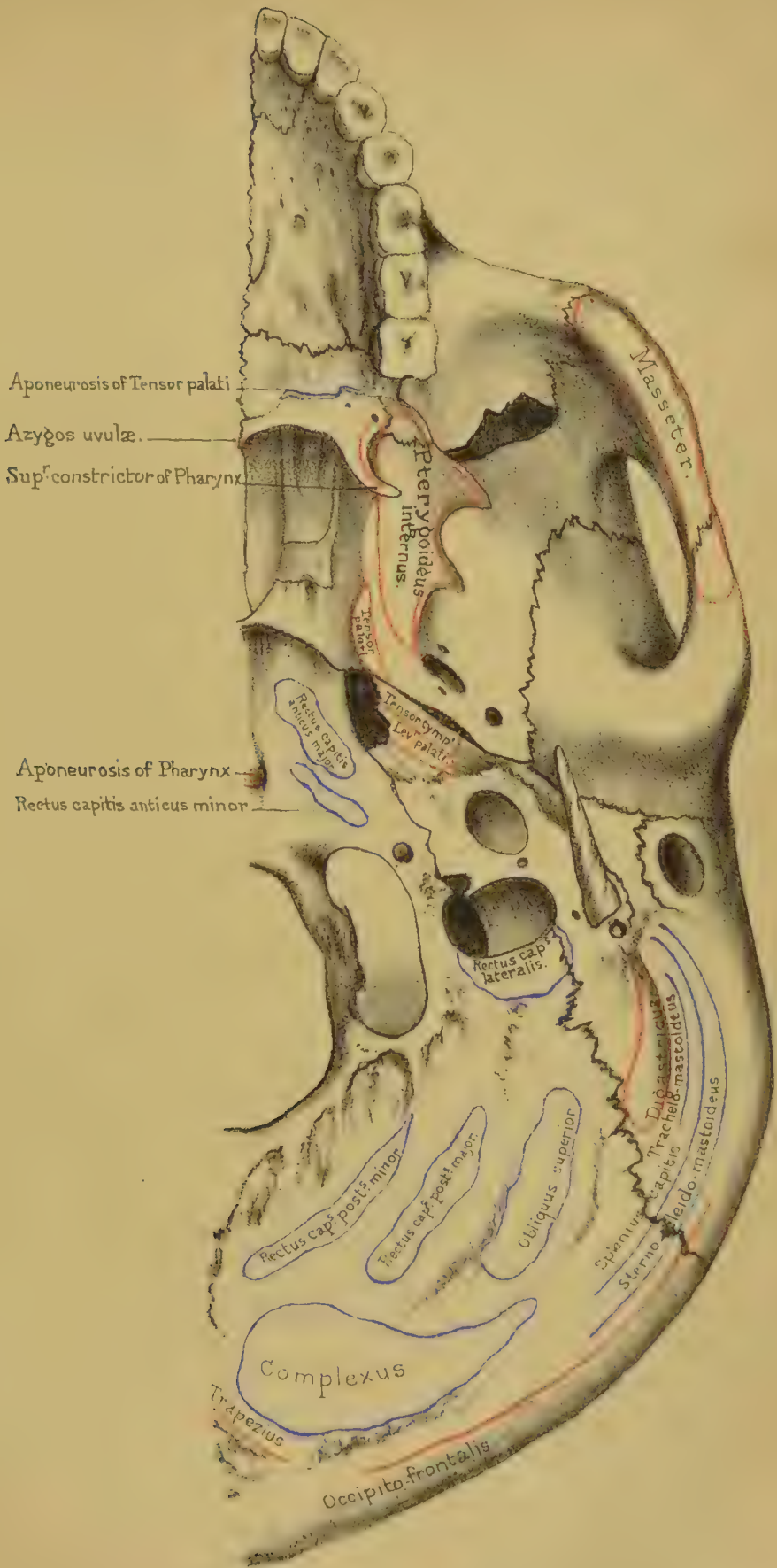
The base of the skull comprises such a wide area, that it is desirable to draw certain limitary lines. If, then, a line be drawn from the first incisor tooth on each side, backwards to the mastoid process, and another transversely, from one mastoid process to the other, we shall describe a triangle within which are contained all the parts usually spoken of as at the base of the skull.

ARCH OF THE PALATE. Commencing at the front, we observe the arch of the 'hard palate,' formed by the superior maxillary and palate bones: its 'middle' and 'transverse' sutures cross each other at right angles. A pin introduced at the point of crossing would touch five bones, the 5th being the vomer. Generally speaking, when the palate presents a fine arch, free from contraction in any direction, the voice is clear and sonorous. The best singers have always well-formed palates. Observe how rugged its surface is for the lodgment of the palatine glands, and how it is riddled with minute holes for the passage of blood-vessels. Behind the incisor teeth is the 'anterior palatine canal.' This is a single orifice below, but double above, so as to open separately into each nostril. It transmits the anterior palatine vessels and nasopalatine nerves.* Near the last molar tooth is the orifice of the 'posterior palatine canal,' formed conjointly by the palate and superior maxillary bones: and from this we trace forwards the 'palatine groove' for the lodgment of the descending palatine vessels and the large palatine nerve. Lastly, there is the 'ridge' on the palate bone for the attachment of the 'tensor palati,' and the 'posterior nasal spine,' to which is attached the 'azygos uvulæ.'

POSTERIOR OPENINGS OF NOSE. Behind the palate we observe the 'posterior openings of the nasal fossæ,' separated by the sharp edge of the vomer. Each opening is somewhat oval, about one inch in the long diameter and half an inch in the transverse. We should remember this in plugging the nostril. It is bounded,

* For a more minute description of the anterior palatine canal, see p. 96.





above, by the body of the sphenoid and the sphenoidal process of the palate bone; below by the horizontal plate of the palate; outside, by the internal pterygoid plate of the sphenoid; and inside, by the vomer. On the roof of each we notice the expanded 'wings' of the vomer, which receive between them the 'rostrum' of the sphenoid; and also the 'pterygo-palatine canal.' This, as its name implies, is formed conjointly by the pterygoid plate of the sphenoid and the sphenoidal process of the palate bone, and transmits nothing of importance beyond a branch of the internal maxillary artery and a pharyngeal nerve from Meckel's ganglion to the top of the pharynx.

PTERYGOID
REGION.

On each side of the nasal openings are the 'pterygoid processes' of the sphenoid. These pterygoid processes answer three purposes:—1. They bound the posterior openings of the nose. 2. They act as buttresses to support the upper jaw-bones behind. 3. They serve for the origin of the powerful pterygoid muscles which grind the food. From the pterygoid fossa, or, more strictly, from the *inner* surface of the external pterygoid plate and the back of the tuberosity of the palate bone which fits into the gap between the pterygoid processes, arises the 'pterygoideus internus;' while the *outer* surface of the same plate and the adjacent outer aspect of the tuberosity of the palate bone give origin to the 'pterygoideus externus.' At the base of the internal plate is the scaphoid fossa, for the origin of the 'tensor palati;' and at the apex is the beautiful pulley, termed the 'hamular process,' round which the tendon of this muscle turns. Besides this, the hamular process gives origin to part of the 'superior constrictor' of the pharynx. Immediately above the 'scaphoid fossa,' we notice the posterior orifice of the Vidian canal.

Proceeding backwards from the base of the pterygoid processes, we come next upon the great foramina at the base of the skull, most of which we have already seen in the examination of the base from within. In the great wing of the sphenoid there is the 'foramen ovale;'* behind this is the 'foramen spinosum;' and

* The foramen rotundum cannot be seen at the inferior part of the base of the skull: look for it at the back of the orbit.

still farther back is the apex of the wing, termed the 'spinous process,' which is wedged between the squamous and petrous bones, and gives attachment to the internal lateral ligament of the lower jaw and the 'laxator tympani.' From the spinous process we trace outwards the 'glenoid fissure,' which runs across the glenoid cavity of the temporal bone. Between the sphenoid and petrous bones is the canal for the 'Eustachian tube' (running in the same line as the *fissura Glaseri*), which is completed in the recent state by fibro-cartilage.

PETROUS
REGION.

The petrous portion of the temporal bone is wedged in between the sphenoid and the basilar process of the occipital. Observe that the apex of the wedge is cut short, so that an irregular opening remains between the three bones, termed the 'foramen lacerum medium.' In the perfect skull this space is filled with cartilage, which serves the purpose of breaking shocks transmitted to the base: remember that through this cartilage pass the internal carotid artery, surrounded with filaments of the sympathetic nerve, and the Vidian nerve. The apex of the petrous bone gives origin to the 'tensor tympani' and 'levator palati.' In the middle of the petrous bone is the wide orifice of the carotid canal which transmits the carotid artery. Trace this canal, and you will find that it does not enter the skull direct, but that it ascends for a short distance, and then runs horizontally forwards and inwards through the petrous bone, till it opens at the apex into the foramen lacerum. Thus the carotid artery makes two curves, like the letter S, before it enters the skull—the first curve in the bony canal, and the second through the cartilage which fills up the foramen lacerum. This disposition of the great arteries at the base is intended to check the force of the blood on its passage to the brain.

Behind the carotid canal is the 'foramen lacerum posterius,' or 'foramen jugulare,' another opening left between the petrous and occipital bones. The size and shape of it is subject to great variety;* but it is generally divided by a projecting tongue of bone into an anterior part, which transmits the eighth pair of

* From an examination of many skulls, I find that the right jugular foramen is larger than the left in point of frequency, as 2 : 1.

nerves, and a posterior, which is by far the larger, for the passage of the blood from the lateral sinus into the commencement of the internal jugular vein. The posterior meningeal arteries (from the occipital and ascending pharyngeal branches of the external carotid) also enter the cranium through this aperture.

FIG. 22.



DIAGRAM OF THE RELATIVE POSITIONS OF THE MORE IMPORTANT PARTS AT THE BASE OF THE SKULL.

The dotted arrow shows that the mastoid process, the stylo-mastoid foramen, the styloid process, and the spinous process of the sphenoid (represented by stars), and the Eustachian tube are pretty nearly in a line.

Outside the arrow are—

1. Scaphoid fossa.
2. Foramen ovale.
3. Foramen spinosum.
4. Spinous process.
5. Fissura Glaseri.
6. Meatus auditorius externus.

Inside the arrow are—

7. Pterygo-palatine canal.
8. Foramen lacerum medium.
9. Carotid canal.
10. Foramen jugulare.
11. Notch for 8th pair of nerves.
12. Anterior condyloid foramen.

Outside the foramen lacerum posterius is the 'styloid process,' projecting, more or less, beyond the 'vaginal process' at its root. Behind this is the 'stylo-mastoid foramen,' through which the facial nerve emerges from, and the stylo-mastoid artery enters, the skull. Still farther back is the mastoid process and the

digastric fossa for the origin of the digastric muscle. Internal to this fossa may generally be seen the groove for the occipital artery.

BASILAR PROCESS. Lastly, we have to notice how the basilar process of the occipital bone projects into the base of the skull, so as to join the body of the sphenoid. Here it forms the roof of the pharynx. This relation is of practical importance. It is well to know that the basilar process is within reach of the finger introduced into the mouth, and that we can explore it satisfactorily, so as to determine how far a polypus may be connected with it. It affords insertion to the 'rectus capitis anticus major' and 'minor,' and (by means of a little tubercle) to the aponeurosis of the pharynx. Behind the basilar process is the 'foramen magnum.' On each side of this are the 'condyles' of the occiput, with the 'anterior' and 'posterior condyloid' foramina; and on the outside of each condyle is the jugular eminence, which gives insertion to the 'rectus capitis lateralis.'

POSITION OF THE OCCIPITAL FORAMEN. In a well-formed European skull, the plane of the occipital foramen is horizontal when the body is erect, and its anterior extremity is about half way between the tuberosity of the occipital bone and the incisors of the upper jaw. This central position of the occipital foramen and the condyles is one of the great peculiarities of man, who is destined to stand erect. His head, therefore, is almost equally balanced on the top of the spine. In monkeys, who hold a middle rank between man and quadrupeds, the foramen magnum is placed farther back: in the orang outan, it is about twice as far from the foramina incisiva as from the back of the head. Consequently, although monkeys can stand erect for a time, they cannot do so long. In quadrupeds, again, the foramen magnum is still nearer to the back of the head, and its plane forms a considerable angle with the horizon. The weight of the head in quadrupeds is sustained not by the spine, but by an elastic ligament of great strength (ligamentum nuchæ), which arises from the lofty spines of the dorsal vertebræ, and is fixed to the middle of the occiput. This ligament is immensely strong in the elephant. A beautiful example, this, of nature's economy. She accomplishes by a lowly

organised structure an object which must else have been gained by powerful muscles well supplied with blood and nerves. In other words, she employs mechanical force to do the work of vital force.

TEMPORAL, ZYGOMATIC, AND SPHENO-MAXILLARY FOSSÆ.

The temporal fossa, of which the description has already been given (page 116), leads into the zygomatic fossa, the boundary between them being the crest of the sphenoid bone.

ZYGOMATIC FOSSA. The 'zygomatic fossa' is bounded externally by the zygomatic arch, which not only serves as a strong buttress to support the bones of the face, but also to give origin to the powerful 'masseter' muscle which closes the jaw.* In front of the fossa there is the back part of the superior maxilla; at the bottom of it, the outer pterygoid plate of the sphenoid, which gives origin to the external pterygoid muscle. At the deepest part of the fossa are two wide fissures at right angles to each other: one, nearly horizontal, leads into the orbit, and is called the 'spheno-maxillary fissure;' through this fissure the infra-orbital nerve and artery enter the floor of the orbit to reach their canal in the superior maxillary bone.

SPHENO-MAXILLARY FOSSA. The other fissure, nearly vertical, leads to the 'spheno-maxillary fossa,' in which the third part of the internal maxillary artery breaks up into terminal branches. Now this fossa deserves particular notice, because there are five openings into it. (Plate XXVI.) Observe, first, its boundaries. In front it is bounded by the back of the superior maxilla; behind, by a smooth surface at the base of the pterygoid process; internally, it is separated from the nasal fossæ by the perpendicular plate of the palate bone.

The five openings into the spheno-maxillary fossa are as follows:—

* The zygomatic arch, in all animals, bears a certain proportion to the size of the muscles of the jaw and the character of the teeth. It is most strongly marked in the Carnivora. In them it is arched both in the horizontal and the vertical direction, to give more room for the temporal muscle, and more power to the masseter. In the ant-eater, which has no teeth, the zygomatic arch is incomplete.

FIVE OPENINGS INTO SPHENO-MAXILLARY FOSSA.

1. Spheno-palatine foramen	{ transmits into the nasal fossa .	{ Internal or nasal branches of spheno- palatine ganglion. Nasal or spheno-palatine branch of in- ternal maxillary artery.
2. Posterior-palatine canal	{ transmits to the palate . .	{ Descending palatine artery and large palatine nerve.
3. Foramen rotundum . . .	transmits . .	{ Superior maxillary nerve, or second division of fifth pair.
4. Vidian canal	transmits . .	Vidian artery and nerve.
5. Pterygo-palatine canal . .	transmits . .	{ Pterygo-palatine branch of internal maxillary artery, and pharyn- geal nerve from Meckel's gang- lion.

THE ORBITS.

The orbits, or sockets for the eyes, are like crypts excavated beneath the cranium. (Plate XXVII.) To use the words of Sir Charles Bell, 'these under arches are groined;' that is to say, they are provided with strong ribs of bone, so that there is no need of thick bone in the interstices of the groinings. The plate between the eye and the brain is as thin as parchment: but look how strong is the arch forming the orbital margin, and what a strong ridge of bone runs up from the zygoma, like a buttress to support the side of the arch. When the eye is retracted in its socket, the margin of the orbit is more than strong enough to protect it from the effects of violence.

Each orbit is pyramidal, with the apex behind. Their axes are not parallel: if prolonged, they would pass through the optic foramina, and meet behind the pituitary fossa of the sphenoid. This divergence gives a greater range of vision.

UPPER WALL OF ORBIT. The upper wall of the orbit is slightly arched, and formed by the frontal bone and lesser wing of the sphenoid.* On this wall we observe—1, the optic foramen; 2, the fossa beneath the external angular process for the lachrymal gland; 3, the little depression for the pulley of the 'superior

* The orbital plates of the frontal bone are more or less arched in different skulls. Of course, the more they are arched the more they encroach on the cranial space, and the less room there is for the anterior lobes of the brain. Compare the skull of a monkey with that of man in this respect, and you will observe a marked difference.

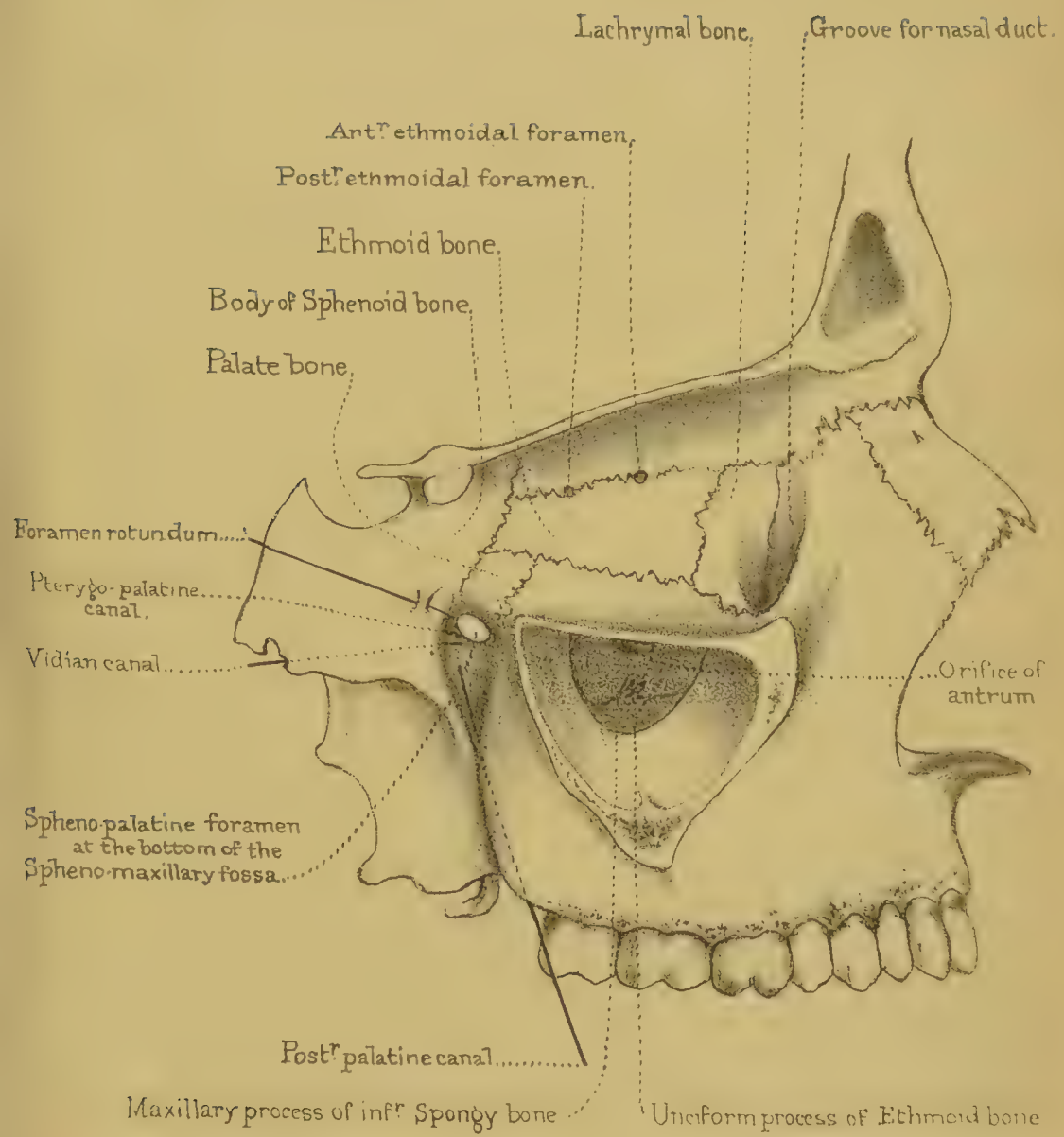


Diagram of the Bones and Foramina
on the inner wall of the Orbit, the five openings into the
Spheno-maxillary fossa, the Antrum and bones contracting its orifice.

oblique' muscle; 4, the supra-orbital foramen or notch, situated at the junction of the inner with the middle third of the orbital margin.

LOWER WALL OR FLOOR OF THE ORBIT. The lower wall of the orbit slopes downwards and outwards, and is formed by the orbital plate of the superior maxilla, by part of the malar bone, and behind by the orbital plate of the palate bone. On this wall there is nothing to observe, except the groove for the infra-orbital nerve.

INNER WALL OF ORBIT. The inner wall (Plate XXVI.) is formed by the nasal process of the superior maxilla, by the lachrymal, the os planum of the ethmoid, and part of the body of the sphenoid bone. Here we observe the groove for the nasal duct, formed conjointly by the nasal process of the superior maxilla, the lachrymal, and the inferior spongy bone. Its direction is downwards, backwards, and a little outwards, and it leads into the inferior meatus of the nose. Besides this, there are the 'anterior and posterior ethmoidal foramina.' (See note, p. 67.)

OUTER WALL OF ORBIT. The outer wall of the orbit is formed by the malar bone and the orbital plate of the great wing of the sphenoid. Here we notice one or two small foramina (malar canals), which transmit small nerves from the orbit to the skin of the cheek and temple. (See p. 99.) Observe that the outer wall of the orbit recedes more than the other parts of its circumference, in order to give a greater range of vision externally. This range is such that by simply rotating the head on each side of the spine, we can see all round.

BONES COMPOSING ORBIT. Thus, seven bones enter into the composition of each orbit: namely—the frontal, ethmoid, and sphenoid, the superior maxilla, the malar, the lachrymal, and the palate; but there are only eleven bones in the two orbits, since three bones are common to both.

SPHENOIDAL AND SPHENO-MAXILLARY FISSURES. At the back of the orbit we find two wide fissures for the admission of blood-vessels and nerves. The upper one is the 'sphenoidal fissure,' formed between the greater and lesser wings of the sphenoid bone. It leads into the cranium, and transmits the third and fourth nerves, the

ophthalmic branch of the fifth, the sixth nerve, some filaments of the sympathetic nerve, and the ophthalmic vein. The lower one, termed the 'spheno-maxillary fissure,' leads into the zygomatic fossa. The borders of this fissure are formed internally by the superior maxillary and palate bones, externally by the sphenoid. It is completed in front by the malar.* Through this fissure the infra-orbital artery and the superior maxillary nerve enter the groove along the floor of the orbit.

There are some points of practical interest about these two fissures. 1. Concerning the *spheno-maxillary fissure* we should remember that in blows on the temple, blood is apt to make its way through the fissure into the orbit, and produce ecchymosis under the conjunctiva. 2. In the operation for the removal of the superior maxillary bone, we saw through the orbital wall into the fissure, so that it is requisite to know its precise position. Concerning the *sphenoidal fissure*, we should know: 1. That in fracture through the base of the skull, involving this fissure, the effused blood is likely to make its way into the orbit and produce ecchymosis of the conjunctiva, which is therefore an unfavourable symptom. 2. That a sharp instrument might penetrate through this fissure into the brain. Surgery has such cases on record. Here is one. Henry II. of France, one of the last princes of the House of Valois, was mortally wounded (in a tournament held in 1559, on the occasion of the marriage of Philip II. with Elizabeth of France) by Montgomery, captain of the body guard. A splinter from a lance entered through the sphenoidal fissure, stuck fast, and could not be extracted. The king died on the eleventh day.

* Except in cases where the sphenoid and superior maxillary come into contact, and exclude the malar. (See *note*, p. 84.)

NASAL FOSSÆ.

(PLATE XX.)

These cavities open widely to the air in front through the nostrils, and behind into the top of the pharynx. To study them properly it is indispensable to have a skull divided longitudinally on one side of the septum, so that we can examine the roof, the floor, the outer and inner surfaces of the cavities.

BOUNDARIES OF NASAL FOSSÆ. The 'roof' of the nasal fossæ is formed by the nasal bones, by the nasal spine of the frontal, the cribriform plate of the ethmoid, and the body of the sphenoid. Observe that it does not form a horizontal line from before backwards. It is only the cribriform plate which is horizontal; from this, the roof slopes forwards towards the nose, and backwards towards the pharynx: therefore the vertical depth is much greater in the middle than elsewhere. Notice the greater thinness of the cribriform plate, and how easily an instrument might be thrust through this part of the roof into the brain. Herodotus,* in his excellent description of the process of embalming the dead, as practised by the ancient Egyptians, mentions that they drew out the brain through the nostrils with an iron hook, and filled up the vacuum by injecting drugs.†

The 'floor' is nearly horizontal, and is formed by the palate plates of the superior maxillary and palate bones. In the dry bones we notice, on each side of the septum, the orifice of the 'anterior palatine canal' (p. 96).

MEATUS OF THE NOSE. The outer wall of the nasal fossæ is made irregular by the 'meatus' or passages in the nose, and the numerous openings leading to the air-cells, excavated in the neighbouring bones. It is formed by the ethmoid (including its two turbinated bones), the nasal, the superior maxillary, the lachrymal, the inferior turbinated, the palate, and the internal

* 'Enterpe,' chap. 86, 87, 88.

† In the fine series of ancient Egyptian skulls, brought from the great necropolis of Thebes by Professor Flower, and now in the Museum of the Royal College of Surgeons, it may be seen that in every one of them the cribriform plate is broken away, and the bones of the nasal fosse more or less damaged; an interesting proof of the veracity of the ancient historian.

pterygoid plate of the sphenoid. Here we have to observe the position of the turbinated bones and the three ‘meatus’ or passages of the nose.* (Plates XX. and XXI.) Beneath the superior tur-

SUPERIOR MEATUS. binated bone lies the ‘superior meatus,’ into which open the posterior ethmoidal cells and the sphenoidal cells. At the back part of this meatus is the sphenopalatine foramen, which leads into the sphenomaxillary fossa.

MIDDLE MEATUS. Below the middle turbinated bone is the ‘middle meatus.’ Into this open—1, towards the front, the frontal sinus (or cell), along a passage termed the ‘*infundibulum*,’ 2, the anterior ethmoidal cells (distinct from the posterior); 3, the antrum or maxillary sinus. The orifice of the antrum, observe, is large and irregular in the dry bones; but in the recent state it is so narrowed by mucous membrane that it will just admit a crow-quill.

INFERIOR MEATUS. Below the inferior turbinated bone is the ‘inferior meatus.’ No air-cells open into this meatus: there is only the termination of the nasal duct or channel which conveys the tears into the nose: this cannot be seen without removing part of the turbinated bone.

To facilitate reference, we subjoin, in a tabular form, the respective openings into the several ‘meatus’ of the nose—

The SUPERIOR MEATUS . receives	{ The sphenoidal cells.
	{ The posterior ethmoidal cells.
The MIDDLE receives	{ The anterior ethmoidal cells.
	{ The frontal cells.
	{ The antrum maxillæ.
The INFERIOR receives	The nasal duct.

Concerning the turbinated bones, it should be noticed that the two upper (belonging to the ethmoid) are delicately channelled for the lodgment of the olfactory nerves. The lower one has nothing to do with the sense of smell, and is coarser in its texture. It is traversed by several canals and grooves, which run from before backwards, and in the recent state contain large veins. The turbi-

* In some negro skulls there are four ‘meatus;’ the fourth being above the superior spongy bone.

Fig. 2.

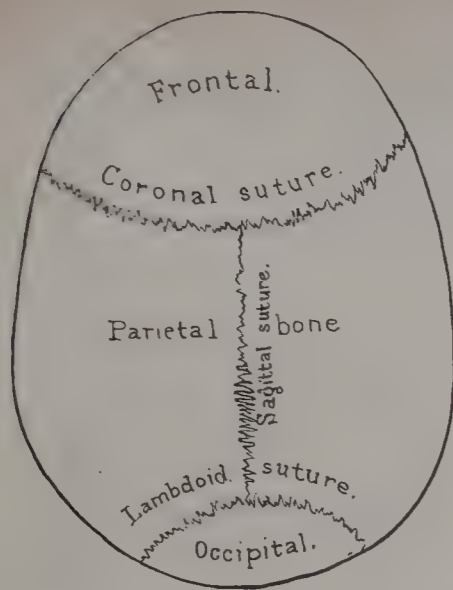


Fig. 1.

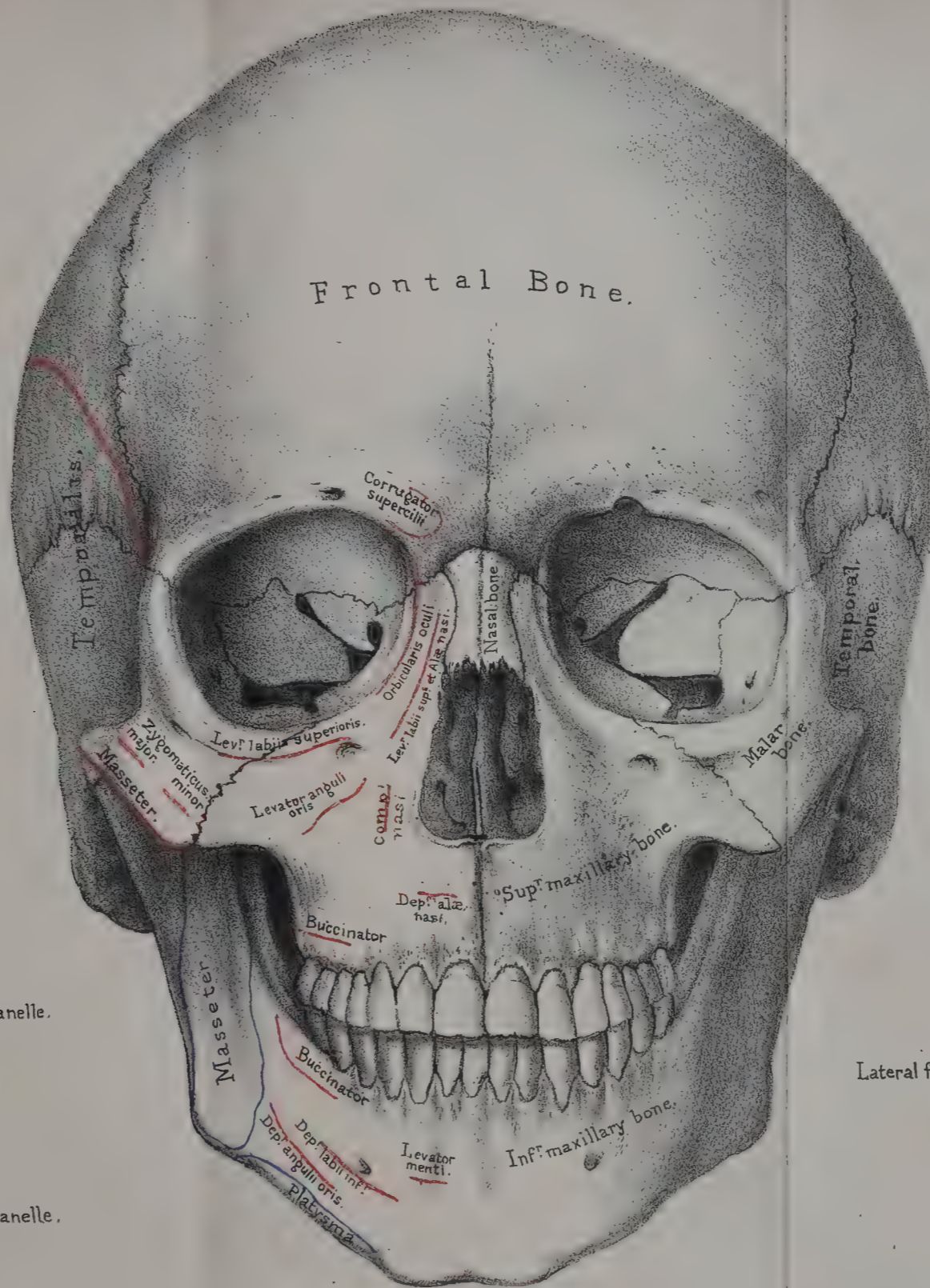


Fig. 3.

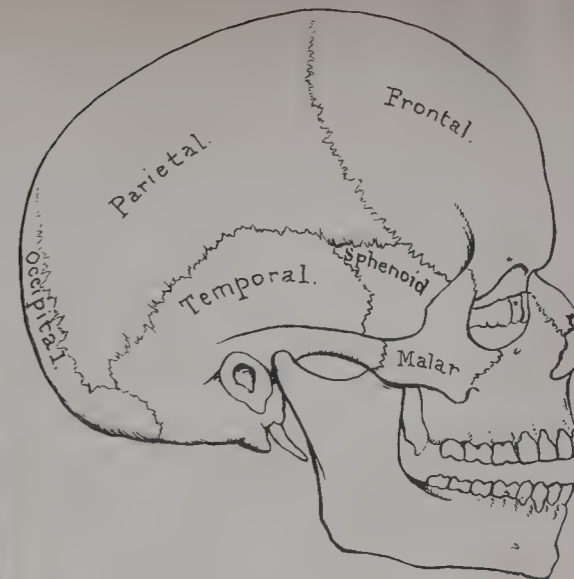
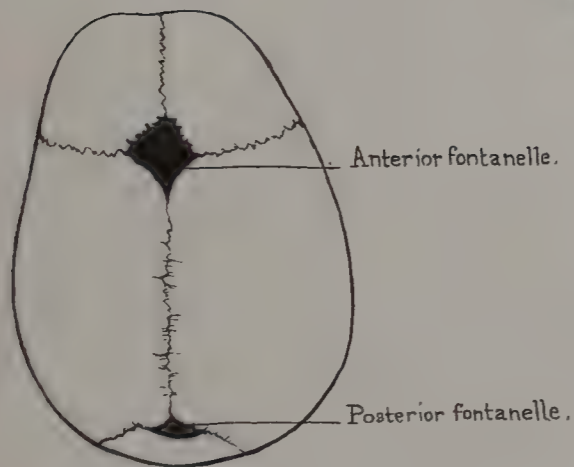
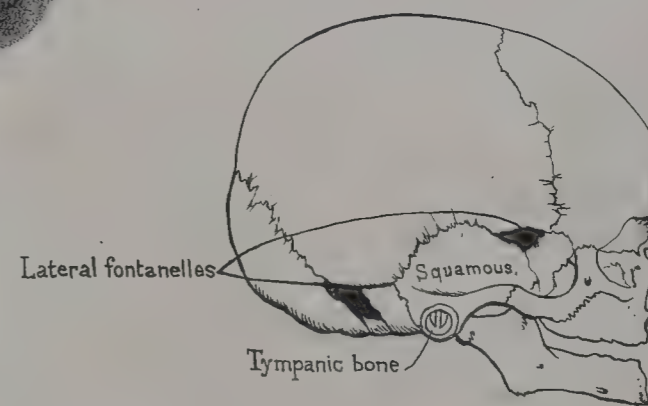


Fig. 4.



Fœtal skull full term.

Fig. 5.



Fœtal skull full term.

nated bones do not extend throughout the whole length of the outer wall. All the surface in front of a perpendicular line let fall from the frontal spine is smooth, as is also all the surface behind a perpendicular line from the spheno-palatine foramen.

BONES FORMING
SEPTUM OF THE
NOSE.

The bony septum of the nose (Plate XX.) is formed *chiefly* by the perpendicular plate of the ethmoid and the vomer. This septum is one of the principal supports of the nasal arch; a piece of architecture at once light and effective. (Plate XXI. fig. 2.) Accurately speaking, however, we ought to mention, as assisting in the formation of the septum, the nasal spine of the frontal, the crests of the nasal, superior maxillary, and palate bones; also the rostrum or crest of the sphenoid: making ten bones in all. The triangular interval left in the septum in the dry skull is filled up in the perfect one by the middle cartilage of the nose, which fits into a fissure in the bone.

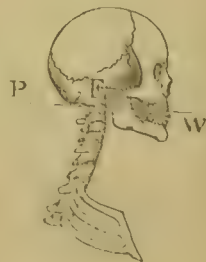
The posterior openings of the nasal fossæ have been already described in the 'base of the skull' (p. 122). It only remains to be said that the anterior aperture is heart-shaped, with the broad part below. It is bounded on either side by the nasal bone, and by the nasal process of the superior maxilla: below it is bounded by the palatine process of this bone, which terminates in front by a sharp projection, termed the 'anterior nasal spine,' the prominence of which is a marked feature in the higher races of mankind. It is very diminutive in some of the lower races and quite absent in monkeys.

GENERAL OBSERVATIONS ON THE SKULL.

SKULL A LEVER
OF THE FIRST
ORDER.

The entire skull represents a lever of the first order. The fulcrum or point of support F (see cut), is at the occipito-atlantoid articulation; the resistance is the weight of the head W; the power P is the mass of muscle attached to the occiput. The lever is not *exactly* balanced on the top of the spine, but very nearly so: and we admire this as one of the many adaptations of the human skeleton for the erect attitude.

FIG. 23.

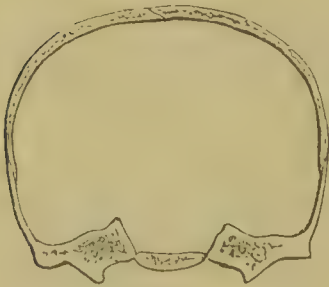


THREE LAYERS
OR TABLES OF THE
SKULL.

The more one examines the skull, the more one sees reason to admire its construction as a case for the protection of the brain. Let us briefly notice a few of the more striking points of it. Look at the structure of the cranial bones. They consist of three layers—an outer, an inner, and an intermediate ‘diploe.’ The outer is formed of compact and tough bone; the inner is harder, but more brittle (hence called ‘tabula vitrea’); while the diploe is softer and spongy, to prevent the transmission of shocks. Altogether, then, this structure may be coarsely compared to a case composed of wood outside, porcelain inside, and soft leather between the two.

The different structure of these three layers or ‘tables’ of the skull is interesting to us, practically, as surgeons. In blows on the head, the inner table, in consequence of its great brittleness, is likely to be broken more extensively than the outer. Cases indeed have occurred, where the inner table has been broken without any injury to the outer. In sabre cuts penetrating the skull-cap as deep as the inner table, Mr. Guthrie* says, that although the cut through the outer table may be only a simple incision without any depression, yet the inner table will be broken almost always to a greater extent than the outer: indeed, it may be separated from it, and driven into the membranes if not into the substance of the brain. Hence the necessity of examining these cases very carefully, in order to ascertain if there be any parts of the inner table depressed, and to remove them.†

FIG. 24.



MECHANICAL
LOCKING OF THE
BONES.

Consider that the bones are mechanically locked together by the sutures; and that in the recent state there is a thin layer of animal matter between their edges, to prevent jarring. The Eddystone Lighthouse is constructed on the same plan. Look at the vaulted form of the cranium, the very best adapted to resist

* ‘Commentaries,’ Lecture xviii.

† Another reason why the inner table is often more extensively splintered than the outer is, that it is the last table reached by the force which inflicts the damage. The

compression. Whoever knows the strength of an egg-shell, can understand what hard blows the cranium will bear. Most of the bones mutually support each other, by having their edges bevelled alternately on opposite sides, as in the frontal suture; or by one overlapping the other, as in the squamous suture, where the temporal prevents the 'starting' of the parietal bone (see cut, fig. 24). The effect of this is, that no single bone can be taken out of the cranium without separating the whole fabric. When we wish to separate the bones, we do so, not by force from without, but by force from within the skull; that is, by introducing peas, which, when moistened with water, swell, and, by pressing equally in all directions, disjoint the bones.

GROINS ALONG
THE SINUSES.

Notice how the interior of the dome is strengthened by 'ribs' or 'groins' of bone, which run in the line of the principal sinuses. One rib extends from the centre of the frontal bone to the foramen magnum, and spans from before backwards the whole arch of the cranium. Another crosses transversely the back part of the occipital bone; the point of intersection of these two ribs being at the occipital protuberance, which is therefore the thickest and strongest part of the skull, for this, if for no other reason, that when a man fall backwards, it is the part which first comes to the ground.

BUTTRESSES OF
THE SKULL.

Like all other arches, the cranium transmits shocks towards its buttresses: these are firmly wedged into the base, and all meet at the centre, that is, at the body of the sphenoid. Looking at the different regions, we find that the frontal part of the arch is supported by the wings of the sphenoid and the malar bones, the parietal part by the temporal bones, and the occipital part supports itself by running, wedge-like, into the base, and abutting on the sphenoid. A knowledge of the buttresses which support the respective parts of the skull-cap affords an explanation of the direction which fractures generally take along the base of the skull, according as the injury has been received on the frontal, the parietal, or the occipital region of the cranium.

aperture of exit of a bullet is larger than that of its entry. (See Erichsen, 'Science and Art of Surgery.')

POWER OF RESISTING SHOCKS.

Béclard, Velpeau, Malgaigne, and generally the older French school, advocate the doctrine that the cranium resists shocks after the manner of other spheres, namely, that a blow struck on one side is transmitted to the opposite one; as when a glass tumbler, struck smartly with the finger nail, is made to crack on the opposite side. This they call fracture by '*contre-coup*.' But the modern school demurs to this doctrine, and contends that the cranium resists shocks like all architectural arches; and that vibrations, instead of going round to the base direct, are lost upon the supporting pillars. Now, what are these pillars? The frontal pillars are the malar and sphenoid bones—the parietal pillars are the temporal bones—the occipital pillars are the ribs of the occipital bone itself. When the head is struck, five times out of six the parietal region is the seat of injury. The bone breaks at the part struck, and the fracture runs on through the temporal, and most frequently through the tympanum, for the very good reason that the tympanum is the weakest part. Observe how many excavations there are in the bone which weaken it about this part: 1, there is the '*meatus auditorius externus*'—2, the cavity of the tympanum itself—3, the jugular fossa—4, the carotid canal—5, the Eustachian tube. This accounts for the frequency of hæmorrhage from the ear in cases of fracture of the base of the skull.

BUTTRESSES OF THE UPPER JAW.

A few words about the architecture of the bones of the face. There are two points to be noticed—1st, the great strength of the nasal arch (Plate XXI.); 2nd, how immovably the upper jaw is fixed by its three buttresses on each side—namely, the nasal, the zygomatic, and the pterygoid. The *nasal* buttresses rest against the internal angles of the frontal bone, and between them is the heart-shaped opening of the nose. The *zygomatic* buttresses are exceedingly strong: they are supported by the external angles of the frontal bone and the zygomatic processes of the temporal, and correspond to the molar teeth, which have to sustain the greatest pressure. The *pterygoid* buttresses descend perpendicularly from the base of the skull, and support the upper jaw behind.

DIMENSIONS OF
THE CRANIUM.

Common observation shows that the shape and relative dimensions of the cranium vary not only in different races of men, but also in individuals of the same race. English, French, and German anatomists have accurately measured the several dimensions of the cranium; but the fact that the statements differ, proves the influence of nationality. The development of the frontal, parietal and occipital regions may be taken as a general expression of the development of the corresponding lobes of the brain. Upon this is founded the study of Craniology.*

FACIAL ANGLE.

The best method of determining the proportions between the cranium and face in man, and the vertebrate animals generally, is by taking what is called the 'facial angle.' Let a line (as shown in the cut) be drawn from the condyle of the occiput along the floor of the nostrils, and be intersected by another line touching the most prominent parts of the forehead and upper jaw: the intercepted angle gives, in a general way, the proportions of the cranial cavity, and the grade of intelligence. In the dog this angle is 20° ; in the chimpanzee it is 40° ; in the Australian 85° ; in the European 95° . The ancients, in their impersonation of the beautiful and intellectual, adopted an angle of 100° .†

FIG. 25.



FACIAL LINE AND ANGLE.

* Craniology is nothing new. An Italian poet in the age of Dante writes:—

‘ Nel Capo son tre celle,
Et io dirò di quelle,
Davanti è lo intelletto
E la forza d’ apprendere;
In mezzo è la ragione
E la discrezione,
Che scerne buono e malo.
Indietro stà con gloria
La valente memoria, etc. etc.

† Froriep (*‘Charakteristik des Kopfes,’* Berlin, 1815) gives tables showing the relative size of the cranium and face in infancy, childhood, and adult age. They go to prove that the *base* of the skull, and the face, as contrasted with the capacity of the cranium, increase from infancy to old age.

BONES OF THE UPPER EXTREMITY.

COMPONENT BONES. THE bones of the upper extremity consist of the 'clavicle,' the 'scapula,' the 'humerus,' the two bones of the fore-arm, namely, the 'radius' and the 'ulna,' the bones of the carpus, the metacarpus, and the phalanges of the fingers. The clavicles and scapulæ form the 'shoulder girdle' or 'pectoral arch.' The length of the arm should always be in exact proportion to the height of the individual. It is a curious fact that, if the arms are fully stretched in the same horizontal line, the space from the end of the middle finger of one hand to that of the other, is about equal to the length of the body.

THE CLAVICLE.

(PLATES XXVIII., XXIX.)

POSITION AND USE. The clavicle, or collar bone, so named from its resemblance to an ancient key, extends nearly horizontally along the upper part of the thorax from the sternum to the scapula. Its chief use is to keep the shoulders wide apart, that the arm may enjoy a freer range of motion. By moving the shoulder, you find that the clavicle acts as a prop, the fixed end of the prop being at the sternal joint.* Hence, in fractures of the

* The clavicle is generally well developed in animals that use their fore limbs for other purposes besides support, such as climbing, flying, burrowing, or holding objects; as exemplified respectively by monkeys, bats, moles, and many rodents. In most birds, the clavicles are ankylosed in front and form a single bone called the 'furculum,' or merry-thought, while the other ends of the fork articulate with the coracoid bone. The chief use of this elastic arch of bone is to resist the action of the great pectoral muscles, which tend to press the humeri inwards towards the mesial plane during the downward stroke of the wing.

clavicle, the shoulder generally drops a little *forwards*. The patient leans his head towards the injured arm so as to relax the muscles, and supports the elbow with the sound hand. Besides its chief use, it serves secondary purposes—such as affording attachment to many powerful muscles, and protection to the axillary vessels and nerves which pass under it.

SHAPE AND
OBJECT OF ITS
CURVES.

The shape of the clavicle is like an italic S. It has two alternate curves, arranged so that, viewed from the front, the sternal or inner half is convex, and the acromial or outer half concave. The sternal curve is the larger of the two, obviously for the purpose of allowing room for the passage under it of the great vessels and nerves of the arm. Another interesting point about the structure of the clavicle is, that the compact wall is much thicker on the concave side of each of its curves than elsewhere. It is about the junction of the two curves that the bone is most frequently broken. These curves not only make the bone stronger than if it were straight, but better able to resist shocks; since, by virtue of its elasticity, the force is partially broken at each of the curves (p. 5). All clavicles are not equally curved: it is less curved in the female than in the male; and as a rule, its strength and degree of curvature depend on the amount of manual labour performed by the individual.

Sir Everard Home* states that French women have longer clavicles than English women, and then proceeds to say that on this account they carry themselves with more grace, the chest being more open. He measured the clavicles of some French women as they lay in bed in Hospital, and found them all six inches long, or nearly so. The clavicles of our English women are not quite so long.

Let us examine, first, the shaft, and afterwards the two ends of the clavicle.

SHAFT.

The shaft of the clavicle bears the impressions of the muscles attached to it. Looking at its upper surface, we observe, on the sternal curve, the origins of the ‘pectoralis major’ and ‘sterno-cleido-mastoideus,’ and on the

* ‘Lectures on Comparative Anatomy,’ vol. v. p. 236.

acromial curve, the origin of the 'deltoides' and the insertion of the 'trapezius.' On its under surface we notice—1, a longitudinal groove for the insertion of the 'subclavius;' 2, a rough surface near the sternal end for the attachment of the 'costo-clavicular' (or rhomboid) ligament; 3, near the acromial end, a tubercle, and a ridge for the attachment of the 'conoid and trapezoid' ligaments (coraco-clavicular): the ridge is about one inch from the scapular end—observe this, because fractures of the bone in this situation are likely to escape notice, in consequence of the ligaments preventing the separation of the fractured ends; 4, near the middle is a foramen for the nutrient artery of the interior.

STERNAL END.

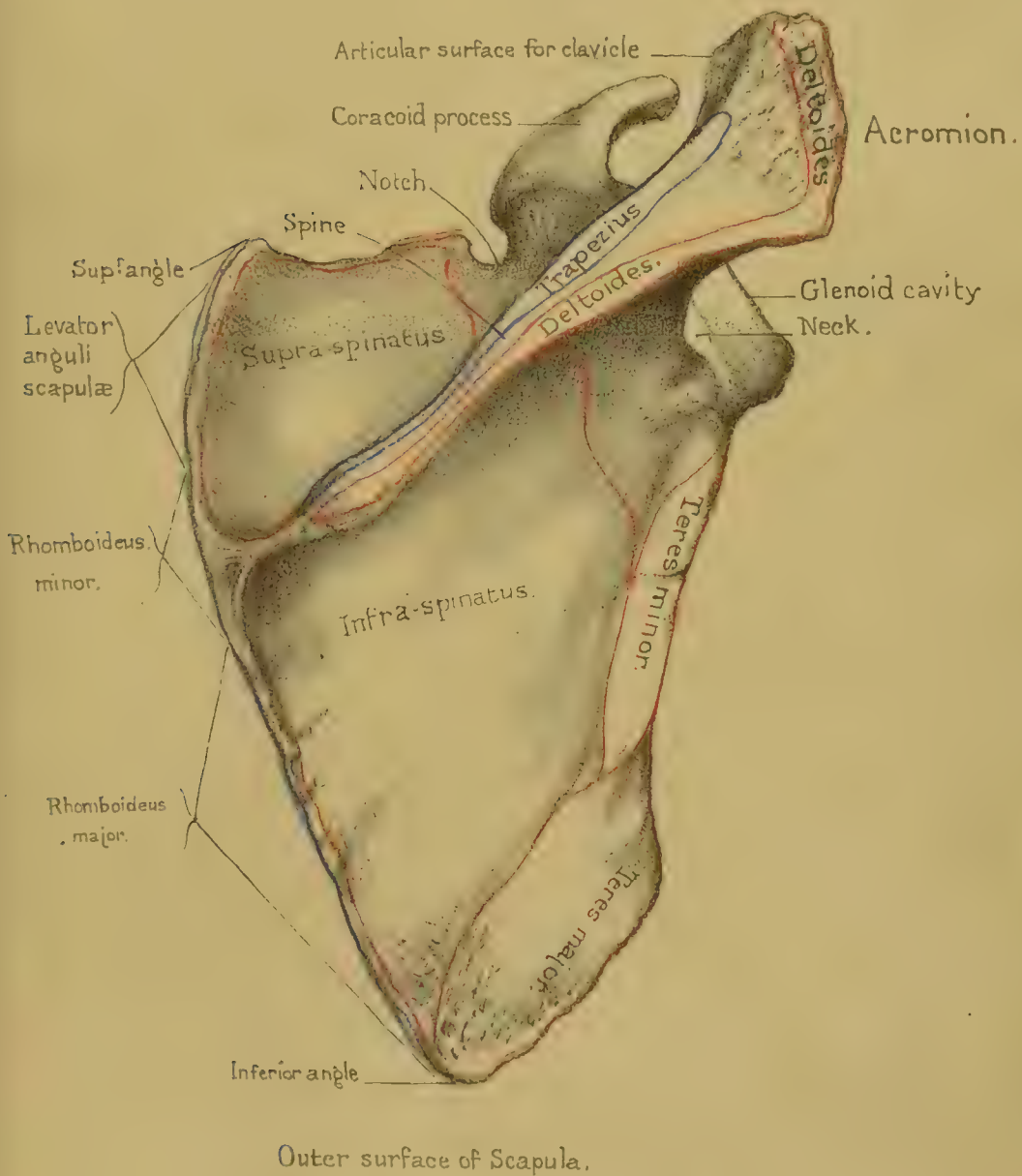
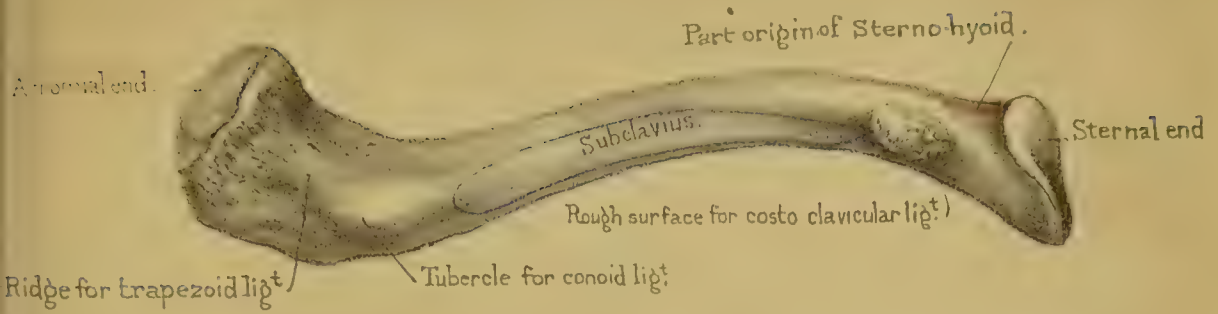
The sternal end of the clavicle is thick, strong, and expanded, to form a base for the prop. It is oblong from before backwards, and articulates, through the medium of an interarticular fibro-cartilage, with the sternum. In the recent state, when crusted with cartilage, the articular surface is slightly convex from above downwards, and concave from before backwards; and moreover, its circumference projects on all sides considerably beyond the articular surface of the sternum, to give more advantageous attachment to the strong ligaments which secure the joint. In consequence of this, dislocation is very rare, notwithstanding the small size of the articular surface of the sternum. A fracture of the clavicle is ten to one more common than a dislocation of its sternal end. In hard-working persons, the sternal end of the bone becomes enlarged, rough, and disfigured. Part of the 'sterno-hyoid' muscle arises from this extremity of the clavicle a little internal and posterior to the rough surface for the rhomboid ligament.*

ACROMIAL END.

The acromial end is broad and flattened, and presents an oblong surface, which looks forwards and slants a little inwards, to articulate with the inner border of the acromion. The plane of this articulation is such that it is very difficult to keep the clavicle in its proper place after a dislocation.

* At the point where the clavicle comes into friction with the cartilage of the first rib, there is often a distinct impression, a sort of improvised articulation blending with the articular surface for the sternum.

Under surface of clavicle



Like all the long bones, its structure is spongy at the extremities, but very compact in the middle of the shaft, where there is a small medullary cavity.

DEVELOPMENT.

The clavicle begins to ossify about the sixth week—that is, sooner than any other bone in the body, and has only one centre of ossification for the shaft. The sternal end has an epiphysis which makes its appearance from the eighteenth to the twentieth year, and subsequently coalesces with the shaft.

THE SCAPULA.

(PLATES XXVIII., XXIX.)

POSITION AND
USE.

The scapula, or shoulder-blade, is placed at the back of the chest. When the arm hangs loosely by the side, the scapula ought to extend from the first rib to about the lower edge of the seventh, and the lower angle should be a little further from the spine than the upper. The inferior angle of the scapula is a good guide to the seventh rib. During life this angle is held down by the upper border of the ‘latissimus dorsi’ and sometimes gives origin to some of its fibres. In emaciated persons the yielding of this muscle allows the lower end of the scapula to project very perceptibly.

The use of the scapula is to afford a movable fulcrum for the motions of the arm, as well as an extensive surface for the attachment of the muscles which effect the movement. It is a flat triangular bone, and so thin in places as to be translucent. We have to examine its two surfaces, its three borders and angles, and its outstanding processes.

OUTER SURFACE.

The ‘outer surface’ of the scapula (*‘dorsum scapulae’*) is slightly convex, and divided into two unequal parts by a very prominent ridge of bone, termed the ‘spine.’ The part above the spine is called the supra-spinous fossa, and gives origin to the ‘supra-spinatus’ muscle; that below

the spine is called the infra-spinous fossa, and gives origin to the 'infra-spinatus.' Near the axillary border are distinct impressions, indicating the origins of the 'teres major' and 'minor' muscles. It is generally marked by the impressions of the '*arteria dorsalis scapulae*.'

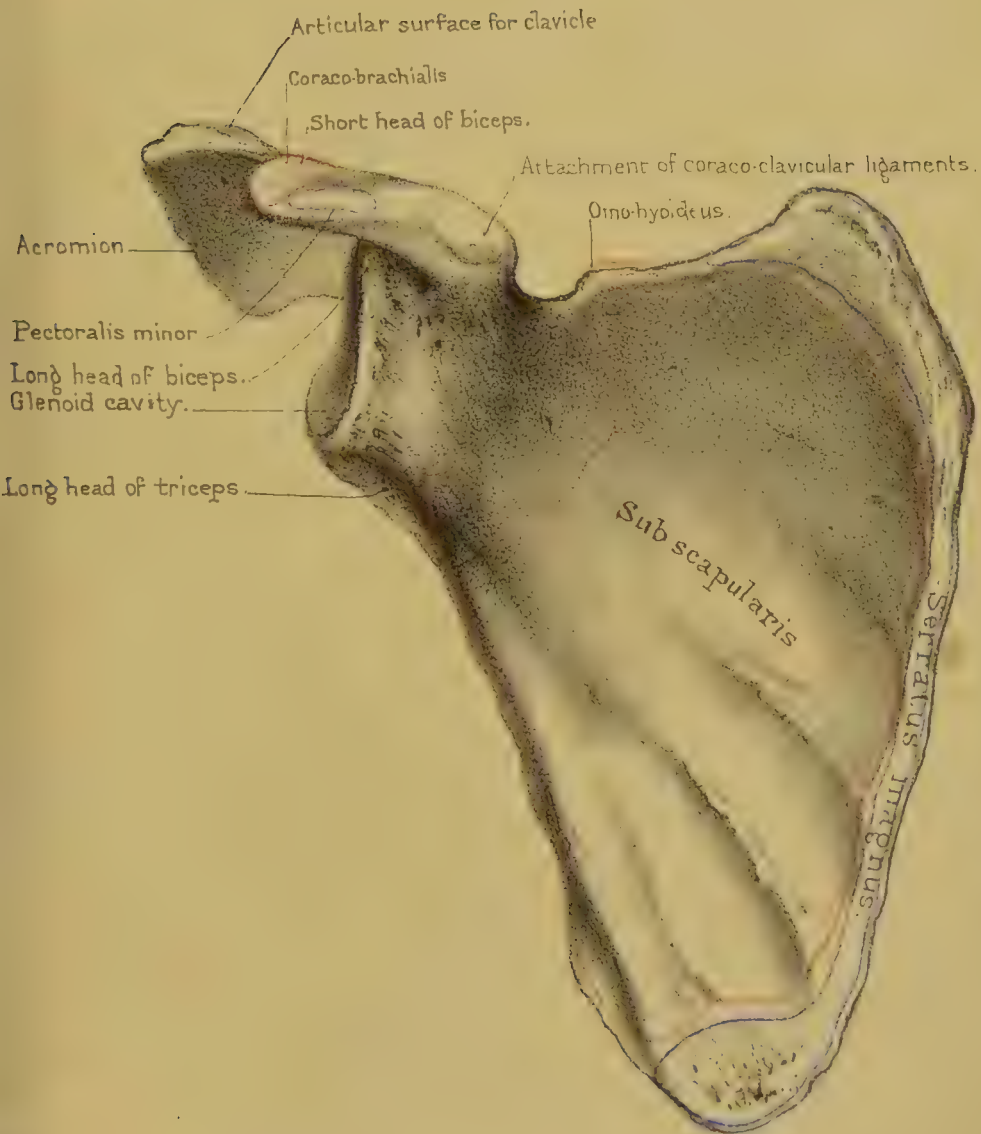
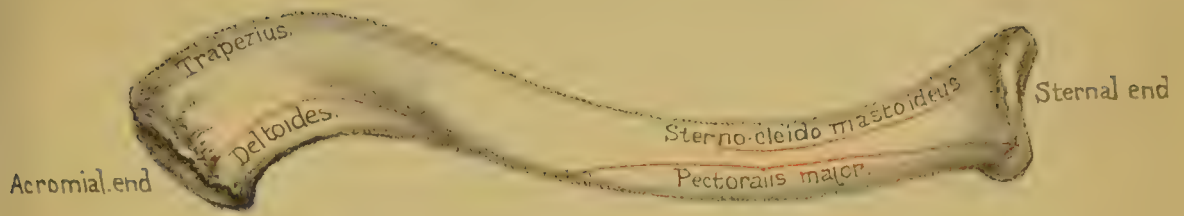
SPINE OF THE
SCAPULA. ACRO-
MION.

The 'spine' of the scapula commences at the posterior border of the bone by a smooth triangular surface over which the tendon of the trapezius plays. From this it soon rises into a high crest, which runs towards the neck of the scapula, where it stands out from the rest of the bone, and suddenly altering its direction at a right angle (which can be plainly felt in the living subject), projects forwards so as to form a lofty arch overhanging the 'glenoid cavity.' This arch is termed the 'acromion' (*ἄκρος ὤμος*). Its purpose is to protect the shoulder joint, as well as to give greater leverage to the powerful 'deltoid' which raises the arm. It is not only a defence, but prevents luxation upwards; without this the head of the humerus would not remain a moment in its socket. It is this process which gives breadth to the shoulder. On the inner border of the acromion is the surface which articulates with the clavicle. Observe that this surface slants from above inwards, so that the clavicle, once dislocated, is with difficulty kept in its place. The end of the acromion gives attachment to the coraco-acromial ligament, which bridges over the gap left in the dry bone between it and the coracoid process, and thus completes the arch for the shoulder. Through this coraco-acromial ligament we pass the point of the knife, in excising the head of the humerus, and thus reach the shoulder-joint in a moment. Reverting to the spine, we observe that it has thick rough borders; above, for the insertion of the 'trapezius,' and below, for the origin of the 'deltoid.'

INNER SURFACE.

The 'inner surface' of the scapula is concave, and called the 'subscapular fossa.' It gives origin to the 'subscapularis,' and presents three or four slanting ridges for the attachment of the tendinous septa by which this muscle is intersected. The hollows between these ridges were mistaken, even by the great anatomist Vesalius, for the impressions of the ribs. On this surface also we observe the insertion of the 'serratus

Upper surface of clavicle.



Inner surface of Scapula.



magnus' chiefly into the rough surfaces on the superior and inferior angles, but also into a very narrow tract along the posterior border.

GLENOID CAVITY. ITS PECULIAR POSITION. The 'anterior angle' of the scapula is the strongest part of the bone, and here we find the 'glenoid cavity' for the articulation of the head of the humerus. This cavity is very shallow, of an oval form, with the larger end downwards, and the long diameter vertical; above all, observe that it looks directly outwards and a trifle forwards; and the reason of this direction is, that the arm may enjoy an extensive range of motion. Its margins are rather prominent and rough, for the attachment of a collar of fibro-cartilage, which slightly deepens the socket. From the upper part of the margin arises the 'long head of the biceps.' Just below the cavity is the origin of the 'long head of the triceps.' Immediately behind the cavity is a slight constriction termed the 'neck' of the scapula. The neck is most plainly seen behind, where it forms with the spine a deep groove (great scapular groove), leading from the supraspinous to the infra-spinous fossa.

When we speak of fracture of the neck of the scapula, we mean fracture behind the coracoid process. This kind of fracture is very rare. It happens to old persons from falling on the shoulder. The shock is received by the head of the humerus, and is thence transmitted to the glenoid cavity. The chief symptom of such an accident is slight lengthening of the arm and dropping of the shoulder. Whoever sees for the first time a fracture of the neck of the scapula, will probably mistake it for a dislocation of the head of the humerus into the axilla. There is in each case the same lengthening of the arm, prominence of the acromion, and flatness of the deltoid; in each case the head of the humerus can be felt in the axilla; but there is *this* important distinction, that in the case of fracture, the normal appearance of the joint can be restored by simply pushing upwards the arm at the elbow, by which means the head of the humerus, with the glenoid cavity, is at once raised to its proper position.

CORACOID PROCESS. From the upper part of the neck of the scapula, just behind the upper margin of the glenoid cavity,

stands off a remarkable projection termed the ‘coracoid* process,’ from its fancied resemblance to the beak of a raven (κόραξ). Arising *from a very broad base*, it takes first a direction inwards, but soon curves forwards towards the acromion, like a half-bent finger, and overhangs the glenoid cavity on the inner side. Its apex is about one inch and a half from the point of the acromion, and on a lower plane. It is necessary to be familiar with the direction of these points of bone, and their accurate bearing to the glenoid cavity and to each other, since they serve as landmarks in determining the nature of obscure injuries about the shoulder. Into the front part of the coracoid process is inserted the tendon of the ‘pectoralis minor,’ and from the ‘apex’ arises the common tendon of the ‘coraco-brachialis,’ and the ‘short head of the biceps.’ At the upper part of its root is a rough surface for the attachment of the ‘coraco-clavicular’ (‘conoid’ and ‘trapezoid’) ligaments which bind down the clavicle; and the border next to the acromion gives attachment to the ‘coraco-acromial ligament,’ which extends across the interval between these points of bone, and completes the arch for the shoulder-joint.

THREE
BORDERS.

The ‘superior border’ of the scapula presents, near the root of the coracoid process, a small notch, which, in the recent state, is bridged over by a ligament. It gives passage to the supra-scapular nerve, and sometimes to the corresponding artery. Behind the notch is the origin of the ‘omohyoideus’ muscle. The ‘posterior border’ is always the longest in man, and is therefore called the base of the scapula: in the lower animals it is generally the shortest. It gives insertion to the ‘levator anguli scapulæ,’ the ‘rhomboideus major,’ and ‘minor’ muscles, and, as before mentioned, to the ‘serratus magnus.’ The ‘inferior or axillary border’ is by far the thickest and strongest, in order to support the glenoid cavity. The deep groove

* The coracoid process is a remarkable bone in birds. In them it is of great strength and solidity, and extends from the sternum to the scapula, where it helps to form the glenoid cavity. It serves as a buttress to support the shoulder during the downward stroke of the wing. This process never articulates with the sternum in any mammal except the duck-bill (*Ornithorhynchus*) and the echidna. In man, it is unusually well developed, in order to give attachment to the muscles which aid the free use of the upper extremity.

along it gives origin to some of the fibres of the 'subscapularis' muscle.

CENTRES OF
OSSIFICATION.

The scapula has six centres of ossification. The 'primary' centre, which appears a little behind the glenoid cavity about the eighth week, forms all parts of the bone, except the coracoid process, the acromion, the inferior angle, and the base; these are cartilaginous at birth. The chief centre of the coracoid process, representing the true coracoid bone, appears soon after birth, and about the fifteenth year unites to the rest of the bone. About puberty, the other secondary centres appear; namely, two for the acromion (one near the summit, the other near the base); one for the inferior angle; and, lastly, one for the border of the base. They all unite to the scapula about the twenty-second year. In a practical point of view it is well to remember that the acromion is not invariably united to the spine by bone. In some rare cases it remains permanently distinct, and is united to the spine only by ligament.

THE HUMERUS.

(PLATES XXX., XXXI.)

The humerus is the longest and strongest of the bones of the upper extremity. It is a lever of the third order, the fulcrum being at the shoulder joint, and the power at the insertions of the several muscles which move the bone. It articulates with the scapula above, and the radius and ulna below. Like all the long bones, we divide it into a body or shaft, and articular ends.

HEAD AND
NECK.

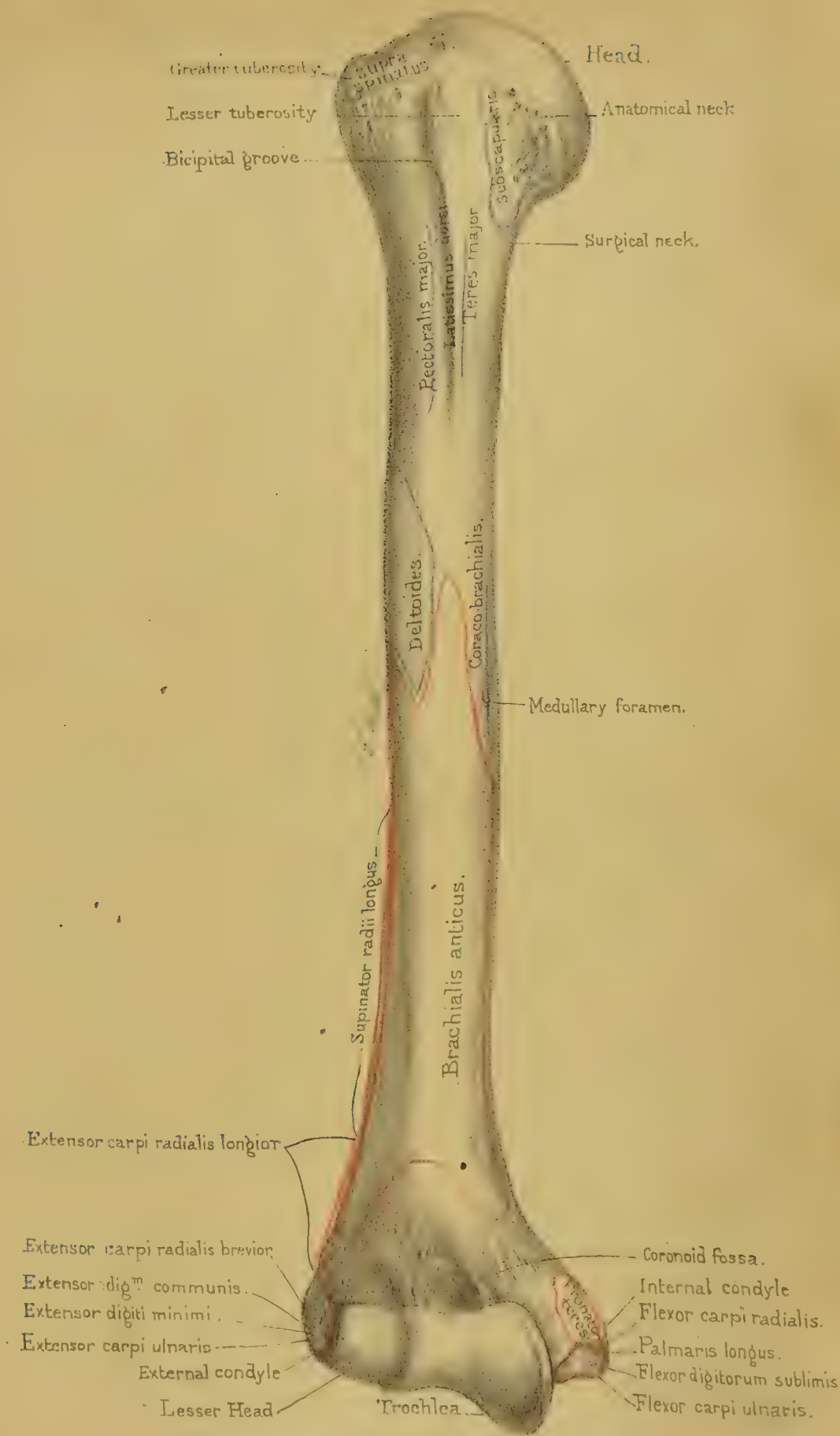
At the upper end, observe the smooth eminence termed the 'head.' It forms about one-third of a sphere, and articulates with the glenoid cavity of the scapula. Observe that the head is much larger than the socket in which it plays. This arrangement, together with the shallowness and direction (p. 143) of the socket, explains the great range of motion which the shoulder-joint enjoys. It is the freest of all the joints, and resembles what mechanics call a 'universal' joint, for there is no part of the body which cannot be touched by the hand. The

head springs from the shaft by a slightly constricted base, called the '*anatomical neck*,' to which the capsular ligament of the joint is attached. Although this is so short and thick as hardly to deserve the name of neck, yet it serves the important purpose of removing the head a little away from the axis of the shaft. In consequence of this, the axis of the head and neck forms an obtuse angle with that of the shaft. When the arm hangs quietly by the side, with the thumb in front, the precise direction of the axis of the head and neck of the humerus is upwards, inwards, and a little backwards from the shaft. The object of this direction is to facilitate rotation inwards, which is more useful than rotation outwards. It is interesting to remark, that this direction is reversed in the axis of the neck of the femur where the object is to facilitate rotation outwards.

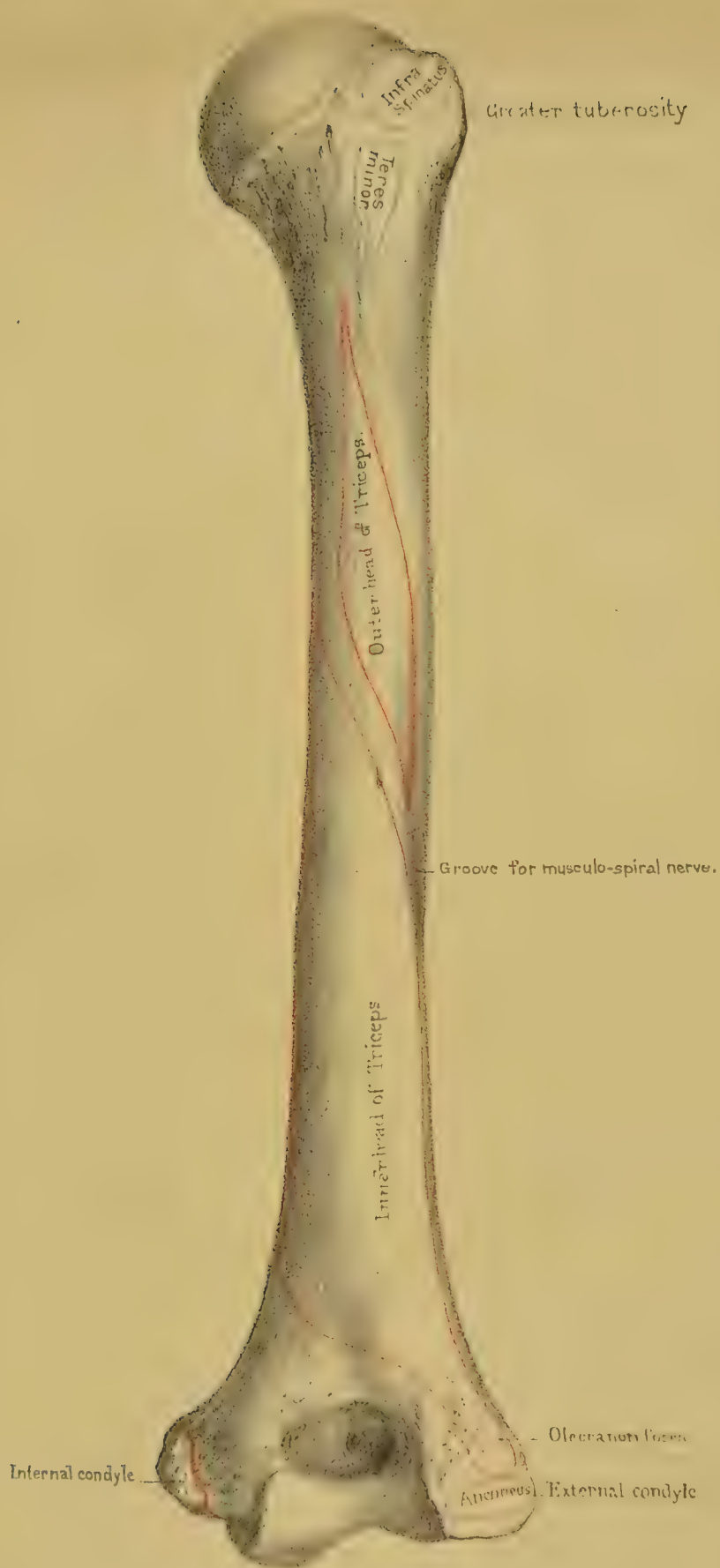
Raise the arm of the skeleton to a right angle, and you observe that much of the lower part of the head of the humerus is out of the socket. This is one of the reasons why the humerus is so liable to be dislocated when the arm is extended; the head of the bone in this position being chiefly supported, below, by the fibrous capsule of the joint. Again, when the arm is raised to a right angle, there is another point worthy of notice. It is this, that the humerus *alone* cannot be raised higher, for the reason that the articular surface of the head of the bone does not admit of elevation beyond a right angle. When we *do* raise the arm beyond a right angle, the additional elevation is accomplished *by the movement of the scapula upon the chest*, an effect principally due to the action of the trapezius and serratus magnus muscles.

GREATER AND
LESSER TUBERO-
SITIES, AND THEIR
USE.

At the root of the neck, or rather at the top of the shaft, are two projections, termed the '*tuberosities*,' of which the use is to give greater leverage to the muscles which move the bone. They are separated by a perpendicular groove which runs some way down the shaft, and is called the '*bicipital groove*,' because the tendon of the long head of the biceps plays in it. In the recent state this groove is bridged over by an aponeurosis, which makes it a complete canal. Of these tuberosities the '*greater*' is the more external; in a thin person it can be plainly felt immediately below



Humerus, posterior view.



Humerus, posterior view.

the acromion. It is useful to know this in determining the nature of injuries about the shoulder. It has three impressions indicating the insertions of muscles, namely—one above and somewhat to the front for the ‘supra-spinatus,’ a second immediately behind the first for the ‘infra-spinatus,’ and a third below the second and quite at the back of the bone for the ‘teres minor.’ The insertion of this last muscle extends beyond the third impression nearly half an inch down the shaft. The ‘*lesser* tuberosity’ is the more internal, and gives insertion to the subscapularis. Lastly, the tuberosities are supported by broad pedicles which run down the shaft, and form, respectively, the outer and inner margins of the bicipital groove.

SHAFT,
BICIPITAL GROOVE
AND SURGICAL
NECK.

We come next to the shaft. The first thing to be observed is, that the lower part of it is twisted inwards, nearly as much as a quarter of a circle ; and that it is slightly curved forwards. The object

of this twist and curve is, to make the axis of motion at the elbow such, that the fore-arm may naturally bend towards the front of the body. Immediately below the tuberosities is the ‘*surgical* neck’ of the humerus ; so called, because, when we speak of a fracture of the neck, we refer to this part of the bone, and not to the ‘*anatomical* neck’ (already described), of which a fracture is rare. On the front of the shaft we notice the bicipital groove, up which the long head of the biceps runs, in order to be attached to the top of the glenoid cavity, so that it may act like a strap to keep down the head of the bone. Up this groove, too, a little artery (a branch of the anterior circumflex) creeps to supply the joint. Into the outer margin of the groove is inserted the tendon of the ‘pectoralis major’ ; into the inner margin the tendon of the ‘teres major’ ; and into the bottom of it the tendon of the ‘latissimus dorsi.’ These muscles play an important part in causing displacement in fracture when it occurs through the surgical neck. There may be a double displacement : *i.e.* the upper fragment is drawn outwards by the muscles inserted into the tuberosities, and the lower fragment is drawn upwards and inwards by the muscles which go from the trunk to the arm.

The middle of the shaft is marked by ridges and impressions

adapted for the convenient action of the muscles. Along its anterior aspect runs a very prominent elevation (the 'anterior border' of some anatomists), continuous with the external border of the bicipital groove. About the middle of the outer aspect there is a

rough impression (*deltoid ridge*) for the insertion of the 'deltoid' which raises the arm. Near this, on the inner aspect, is a smooth surface for the insertion of the 'coraco-brachialis.' Against this surface the brachial artery can be effectually compressed. The surface looks forwards and inwards, and as the artery runs along it, the surgeon must remember this obliquity and apply compression in the proper direction—outwards and backwards—else the artery will slip off the bone. Here also is generally situated the foramen for the nutrient artery of the marrow, which runs from above downwards. Below the deltoid ridge the shaft begins to be twisted, and becomes gradually flattened and expanded for the formation of the articular end. It is generally below the insertion of the deltoid that ununited fractures of the humerus are met with, partly on account of the injury to the nutrient artery of the medulla, and partly on account of the action of the deltoid in causing a displacement of the upper fragment over the lower.

CONDYLOID RIDGES.

The lower half of the shaft presents two ridges, one on each side, called respectively the 'internal' and 'external condyloid ridges,' because they lead to the 'condyles' or points of bone which project on each side of the elbow. The *external* ridge begins just behind the insertion of the deltoid, and is the more prominent of the two; its upper two-thirds give origin to the 'supinator radii longus,' and its lower third to the 'extensor carpi radialis longior.' It is called the *supinator* ridge, and is generally best developed in animals which possess great power in the fore-feet and paws for fighting, digging, etc. It is rather feebly marked in man, considering the mobility and strength of his fore-arm; but in our species the 'supinator longus' is not so much a supinator, as a powerful assistant to the biceps and brachialis anticus in flexing the elbow. The *internal* ridge serves for the attachment of the 'internal intermuscular septum.' The front surface of this part of the shaft gives origin to the

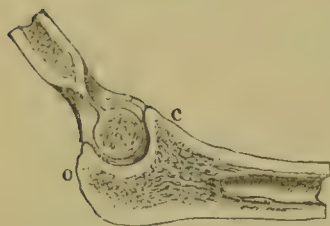
‘brachialis anticus,’ which begins by two little tongues, one on each side the insertion of the deltoid.

The back part of the shaft is occupied by the origins of the outer and inner ‘heads of the triceps,’ which are separated by a groove directed in a spiral manner downwards and outwards for the passage of the musculo-spiral nerve and superior profunda artery. The origin of the outer head is narrow, and lies external to and above the groove, extending as high as the insertion of the teres minor. The origin of the inner head is below the groove, reaching as high as the lower limit of the teres major and covering all the lower part of the shaft, even to the external condyle.

~ The lower end of the humerus curves slightly forwards, and presents a pulley-like surface, beautifully adapted to suit the flexion and extension, as well as the rotatory movement of the fore-arm. On the outer side, we observe the ‘lesser head’ (capitellum) which corresponds with the shallow cavity at the end of the radius. The chief point about this head is, that it projects directly forwards, so that when the fore-arm is bent there is a smooth surface ready for the rotation of the radius. On the inner side is the ‘trochlea’ or pulley for the ulna. This admits of flexion and extension only. The direction of this pulley is oblique; that is, it slants from behind forwards, and from without inwards, so that the fore-arm, in the act of bending, comes naturally in front of the chest. Observe that the inner border of the trochlea descends much lower than the outer, thus protecting the ulna from dislocation inwards. Above the trochlea there is a deep cavity in front (*coronoid fossa*) to receive the coronoid process of the ulna in flexion; and a similar one behind (*olecranon fossa*) to receive the ‘olecranon,’ or the point of the elbow, in extension of the fore-arm. External to the coronoid fossa, immediately above the lesser head, is a shallow depression to receive the head of the radius in extreme flexion. Between the ‘olecranon and coronoid fossæ’ the bone is thin enough to be translucent, as is well seen in the woodcut, fig. 26, which exhibits a section through the joint. In consequence of this thinning of the bone, a transverse fracture through the humerus in this situation is not

uncommon. From the displacement produced so close to the elbow joint this accident is very liable to be mistaken for a

FIG. 26.



SECTION TO SHOW THE TROCHLEA OF THE HUMERUS.

o. Olecranon.

c. Coronoid process.

CONDYLES.

Respecting the two condyles, we observe, that the *internal* projects the most, since it gives origin to the powerful pronator and flexors of the hand and fingers, namely, to the ‘pronator radii teres,’ ‘flexor carpi radialis,’ ‘palmaris longus,’ ‘flexor digitorum sublimis,’ and ‘flexor carpi ulnaris.’ The internal lateral ligament of the elbow is also attached to it. The *external* condyle gives origin, in front, to the common tendon of the extensor muscles; namely, the ‘extensor carpi radialis brevis,’ ‘extensor digitorum communis,’ ‘extensor minimi digiti,’ and ‘extensor carpi ulnaris’: behind, it gives origin to the ‘anconeus.’ Lastly, the external lateral ligament of the elbow is attached to it.

CENTRES OF OSSIFICATION.

The humerus has seven centres of ossification. There is one for the shaft. About the second year after birth the centre of the head appears; and about the third year, the centre of the tuberosities. About the end of the fifth year, the centres for the head and tuberosities have coalesced, so as to form a large epiphysis on the top of the shaft. It is necessary to remember that this epiphysis includes the tuberosities (as shown in the woodcut, fig. 27). On the inner side, the line of junction runs close to the cartilage on the head of the bone: therefore, in the event of separation, the shoulder joint would certainly be implicated. The epiphysis does not unite with the shaft till the twenty-first year: so that up to that

dislocation of the radius and ulna backwards. The celebrated French surgeon, Dupuytren, used to say that there was nothing more common than such a mistake. However, the bearing of the condyles with respect to the olecranon enables us in most cases to determine the diagnosis. If the olecranon be higher than the condyles, there is dislocation of the elbow; if not higher, the ulna is in its proper place.

age it is liable to be separated from the shaft by violence, as we often see in practice. About the beginning of the third year ossification of the lower end commences by a fourth centre in the lesser head. About the fifth year, a fifth centre appears in the internal condyle. About the twelfth year, a sixth centre appears in the great sweep of the trochlea; and, lastly, about the fourteenth year, the seventh centre appears in the external condyle. At the close of the sixteenth year the lower end has completely ossified, and then unites to the shaft. A separation of the lower epiphysis of the humerus is by no means an infrequent accident in children. The lower fragment is carried backwards with the bones of the fore-arm, so as to cause considerable displacement.

FIG. 27.



EPIPHYSIS OF
THE HEAD OF
THE HUMERUS,
SHOWING THAT
IT INCLUDES
TUBEROSITIES.

It is interesting to remark, that the epiphysis of the upper end, though the first to ossify, yet remains separate from the shaft about three or four years longer than that of the lower end. This is in accordance with the rule, that, of the two epiphyses of a long bone, that towards which the nutrient artery of the marrow runs is always the first to unite with the shaft. Remember, that the nutrient arteries of the marrow of the bones of the upper extremity run *towards* the elbow. In the bones of the lower extremity, they run *from* the knee.

T. E. F. K.

THE RADIUS.

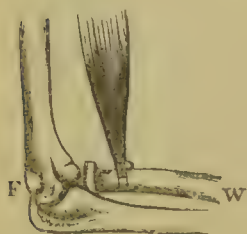
(PLATES XXXII., XXXIII.)

The radius is the external of the two bones of the fore-arm, and is so called from its resemblance to the spoke of a wheel. In learning this bone, keep in mind that both its ends are constructed so as to rotate upon the ulna, and admit of the pronation and supination of the hand. Look at a well-articulated skeleton, and observe that the axis of this rotation is represented by an imaginary line drawn from the centre of the head of the radius to the centre of the circle of which the sigmoid

AXIS OF ROTATION.

cavity at the lower end is a segment: in other words, to the centre of the lower end of the ulna. The lower end of the radius is much larger than the upper, because it is the chief support of the hand: and since the radius receives all shocks from the hand, it is more

FIG. 28.



BONES OF THE FORE-ARM
LEVERS OF THE THIRD
ORDER.

HEAD, NECK,
AND TUBERCLE.

liable to be broken than the ulna.

Like the humerus, the radius and ulna are both levers of the third order, as seen in the cut, fig. 28. The fulcrum F is at the elbow joint—the weight W is the fore-arm—the power P is the insertion of the biceps. The biceps will act to the greatest advantage when the arm is bent to a right angle, because the power acts at a right angle to the lever.

The upper end of the radius is called the 'head:' it has a shallow circular cup, which articulates (when the fore-arm is bent) with the lesser head of the humerus, and in the recent state is held in its place by the strong 'orbicular' ligament which encircles it. Observe that the head has a smooth circular border, adapted to rotate in the lesser sigmoid cavity of the ulna. This rotation of the radius can be distinctly felt below the external condyle of the humerus; a fact of great value in determining the existence of fracture or dislocation. Below the head, is the constricted part termed the 'neck;' and below this, is the 'tubercle' which gives insertion to the tendon of the 'biceps.' Notice that this tubercle projects on the inner side of the bone, so that the biceps can *supinate*, as well as *bend* the fore-arm; notice also that the posterior half of the tubercle is rough for the insertion of the tendon: the anterior half is smooth and is the seat of a bursa which facilitates the play of the tendon.

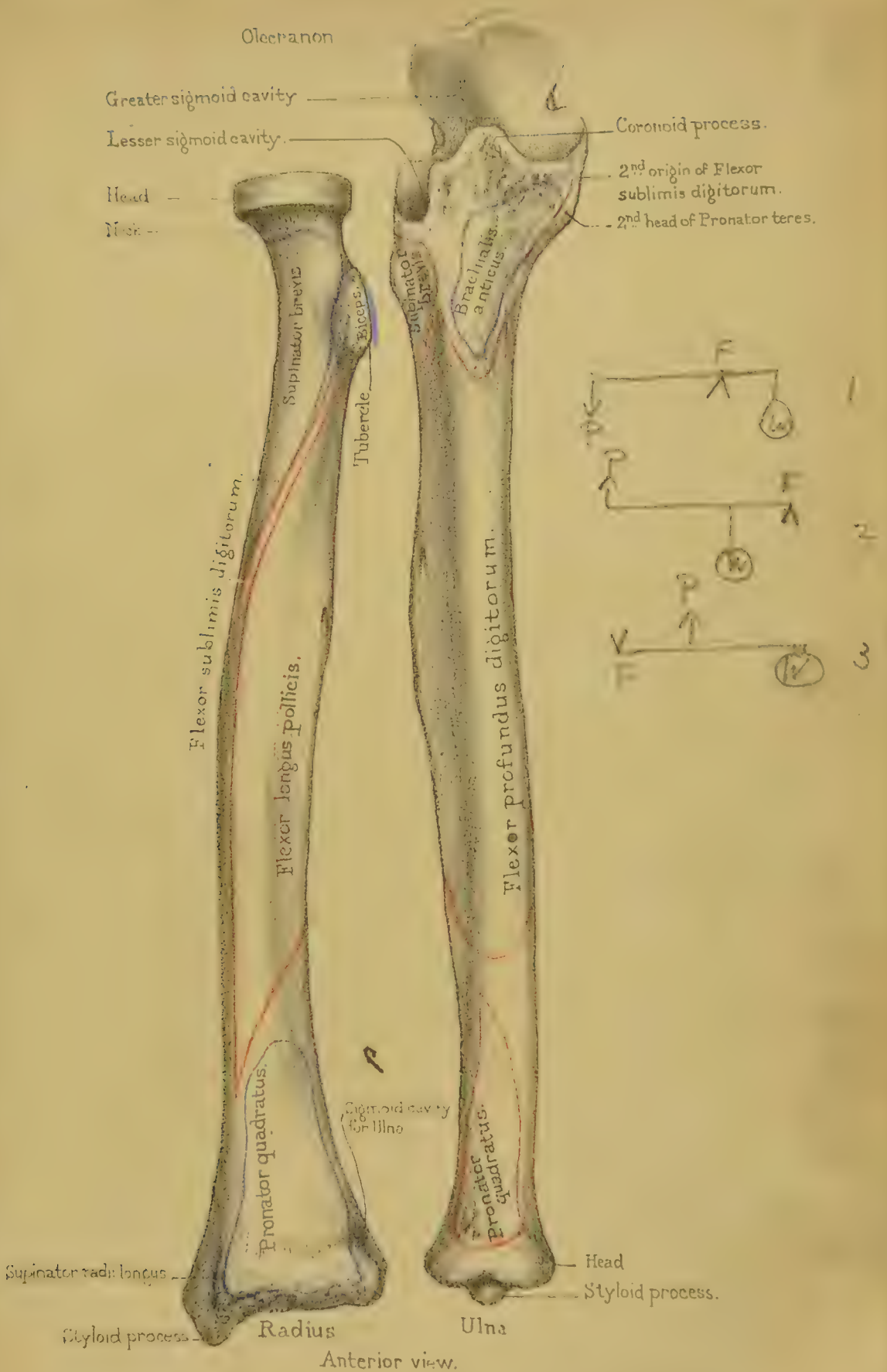
SHAFT.

Respecting the 'shaft,' we observe that its outer side is thick and rounded; and that from this side

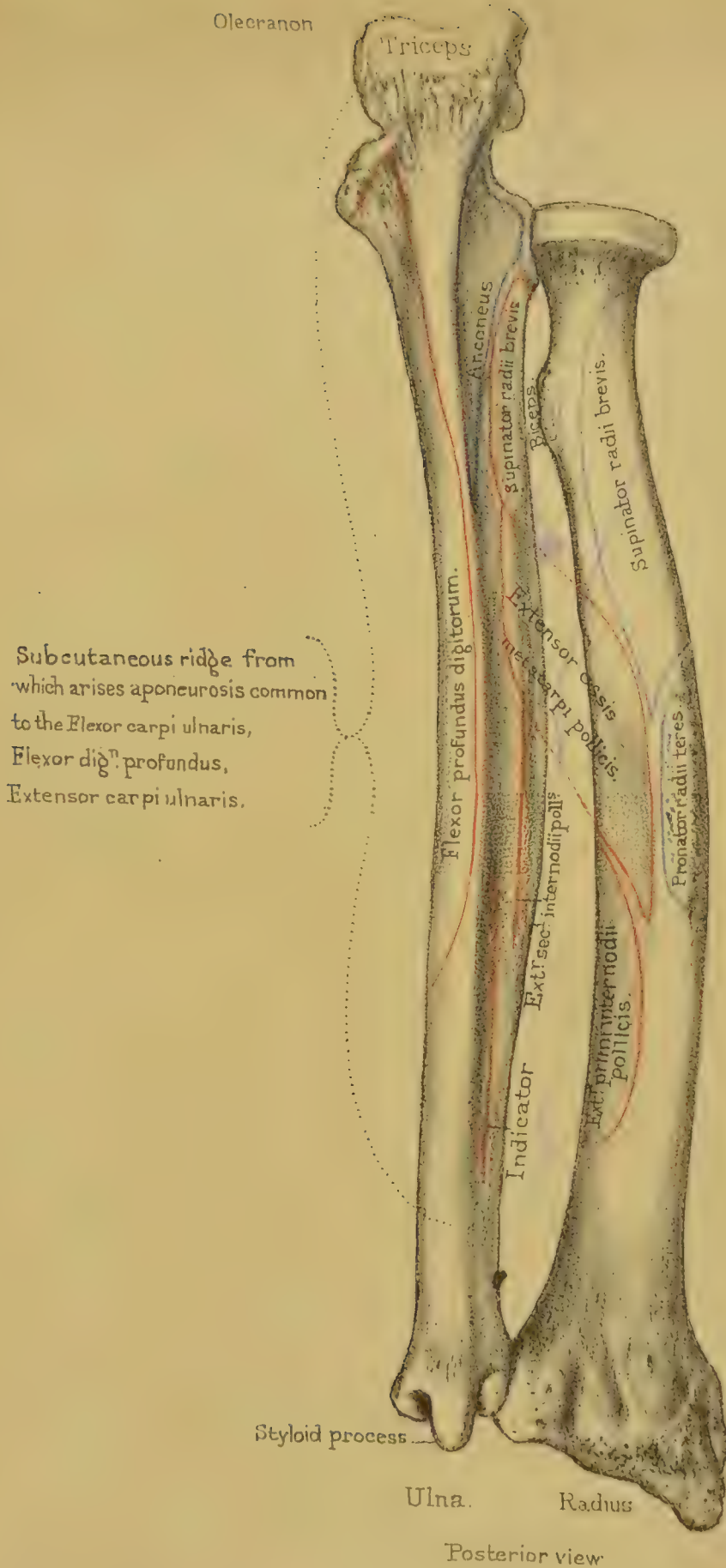
FIG. 29.



its front and back surfaces gradually converge to a sharp edge, which faces the ulna (as seen in the annexed cut, fig. 29), and gives attachment to the interosseous ligament. The shaft is slightly arched outwards, for two reasons—1, because it







increases the breadth of the fore-arm; 2, because it gives more power to the 'pronator teres.'* The bones are furthest apart when the hand is placed vertically with the thumb upwards: hence, fractures of the fore-arm are put up with the hand vertical, that there may be less risk of the opposite bones uniting.

On the front surface of the shaft there is a blunt ridge leading from the tubercle obliquely towards the outer side of the bone. It gives origin to part of the 'flexor sublimis digitorum.' Above this ridge is the insertion of the 'supinator brevis,' and below it is a slightly excavated surface for the origin of the 'flexor longus pollicis.' Below this is the insertion of the 'pronator quadratus.' On the outer and *back* part of the middle of the shaft is a rough surface for the insertion of the 'pronator teres.' Observe that this insertion is into the outer and *back* part of the shaft, in order that the muscle may pronate with greater power. In amputation of the fore-arm it is desirable to saw through the bones below the insertion of this muscle, that the stump may have the benefit of a pronator.

The posterior surface of the shaft is marked by the origin of the extensor muscles of the thumb; namely, the 'extensor ossis metacarpi pollicis,' and the 'extensor primi internodii pollicis.'

LOWER END.

The lower end of the radius expands into a surface slightly cupped transversely, as well as from before backwards, in order to articulate with the 'scaphoid' and 'semilunar' bones of the carpus. In the recent state, if not in the dry bone, this surface is divided by a slight ridge: the part for the 'scaphoid' is triangular, while that for the 'semilunar' bone is square. On its inner side is the concave articular surface ('semilunar' or 'sigmoid' cavity), which rotates upon the lower end of the ulna. On its outer side is the conical projection, termed the 'styloid' process, of which the apex gives attachment to the external lateral ligament of the wrist; while the base gives insertion to the tendon of the 'supinator radii longus.' In front, the lower end has a rough and elevated margin for the attachment of

* The radius of the skeleton of the gorilla in the Museum of the College of Surgeons is extremely arched. The power of his arms is enormous.

the powerful anterior ligament of the carpus: and behind there are four grooves for the passage of the extensors of the wrist and fingers. (Plate XXXVI.) Beginning from the outer side, we observe: 1, a groove for the 'extensor ossis metacarpi pollicis,' and the 'extensor primi internodii pollicis'; 2, a groove for the 'extensores carpi radiales, longior' et 'brevior'; 3, a very distinct and slanting groove for the 'extensor secundi internodii pollicis'; 4, a groove for the 'extensor indicis' and the 'extensor communis digitorum.' In the recent state these grooves are made complete canals by the 'posterior annular ligament.'

The lower end of the radius is composed of cancellous tissue covered by only a thin layer of compact bone, as shown in the ad-

FIG. 30.



SECTION THROUGH
THE LOWER END OF
THE RADIUS, TO
SHOW THE THIN-
NESS OF ITS COM-
PACT WALL.

joining cut, fig. 30. In falls, therefore, upon the palm of the hand; the lower end of this bone, which receives the full force of the shock, is very liable to be broken transversely about half of an inch or one inch above the wrist joint. This fracture of the radius is commonly called Colles's fracture, after the Irish surgeon who first accurately described it. The lower fragment with the hand is thrown backwards so as to make an unnatural swelling on the back of the fore-arm: the upper fragment protrudes on the palmar aspect of the fore-arm just above the wrist. Now a fracture with such displacement is liable to be mistaken for a dislocation of the wrist. How are

we to determine between the two injuries? We must feel for the styloid process of the radius. If the styloid process be in the same line with the shaft of the radius, the injury is probably a dislocation of the wrist backwards: if it be not in the same line, then the injury is probably a fracture of the lower end of the radius, which is by far the most frequent accident of the two.

CENTRES OF OS-
SIFICATION.

The radius has three centres of ossification: one for the shaft, and one for each end. The upper end begins to ossify at the fifth year, and is united at the seventeenth. The lower end begins about the second year, and is not united till the age of eighteen or twenty. This is in accordance

with the general law, that epiphyses unite with the shafts in the inverse order of their ossification.

THE ULNA.

(PLATES XXXII., XXXIII.)

The ulna, so called because it forms the elbow (*ὠλένη*), is the inner of the two bones of the fore-arm.

UPPER END.

Its upper end presents a deep semicircular cavity, with a smooth ridge at the bottom, which accurately fits on the trochlea of the humerus, and forms a perfect hinge-joint admitting of flexion and extension only. (See fig. 31.) This is called the 'greater sigmoid'* cavity, in contradistinction to a smaller one, termed the 'lesser sigmoid,' which is placed on its outer side, and forms a socket for the rotation of the head of the radius. In

FIG. 31.



front of the greater sigmoid cavity is a rough projection, termed the 'coronoid

process' (*κορώνη*, the top of a curve), the rough surface in front of which gives insertion to the 'brachialis anticus' (a flexor of the fore-arm) and origin to the second head of the 'pronator teres,' and the second head of the 'flexor sublimis digitorum.† Besides this, it limits the flexion of the fore-arm. When the arm is bent to an angle of about 40°, the point of the process strikes against the fossa at the lower part of the humerus. In dislocation backwards the coronoid process is very liable to be broken: this complication makes reduction more easy, but subsequent retention of the bones in their proper place more difficult. Violent action of the brachialis anticus may break off the coronoid process: but

* So called from its fancied resemblance to the letter Sigma, which the Greeks originally used in the form of the English C.

† Very often the coronoid process gives origin to a second head of the flexor longus pollicis.

this is very rare. Mr. Liston mentions an instance which happened to a boy about eight years old, in consequence of hanging with one hand from the top of a high wall. When it *is* broken, the coronoid process unites by ligament, owing to the action of the brachialis anticus. At the base of the coronoid process, below the insertion of the 'brachialis anticus,' is a rough tubercular elevation for the insertion of the oblique ligament, the other extremity of which is attached to the radius just below the tubercle for the biceps.

OLECRANON.

Behind the sigmoid cavity is the 'olecranon process' (ὠλένη, elbow, and κρᾶνον, head). This serves many purposes and plays an important part in the perfection of the hinge of the elbow-joint. It gives advantageous leverage to the 'triceps,' which is inserted into it and extends the fore-arm. It forms a convenient knob of bone for the protection of the joint when we lean on the elbow, and it limits the extension of the fore-arm. The surgical interest about it is, that it is sometimes broken by a fall upon the elbow; and the fracture generally takes place just at the slight constriction or notch where the olecranon joins the shaft: so that the joint is involved in the mischief. Fractures of the olecranon, like those of the patella and coronoid process, unite, generally, by ligament, because it is so difficult to keep the fragments in apposition. But if the tendinous expansion from the triceps be not torn, then the union may take place by bone.

In almost all injuries about the elbow joint, however swollen the parts, one can always feel the olecranon and the internal condyle of the humerus. In determining, therefore, the nature of obscure injuries about this joint, it is a useful practical rule to know that, when the arm is extended, the tip of the olecranon and the internal condyle are about one inch apart and in the same transverse line. When the arm is bent to a right angle, the olecranon is $1\frac{1}{2}$ inch from the condyle and below it. By this test we can distinguish between dislocation of the ulna backwards and fracture through the lower end of the humerus.

SHAFT.

The shaft of the ulna is triangular, and tapers gradually from the upper towards the lower end,

which inclines a little outwards towards the radius and terminates in the little ‘*head*’ round which the radius rolls. A transverse section, seen in the cut, fig. 32, shows the shape of the radius and ulna about the middle. We observe that their sharp edges are turned towards each other, and that to these is attached the interosseous membrane which connects the bones. Together, they form a shallow concavity in front and behind, convenient for the lodgment of the muscles of the fore-arm.

FIG. 32.



The greater part of the front as well as of the inner surface of the shaft is occupied by the origin of the ‘*flexor profundus digitorum*.’ On the front, too, we see the canal for the nutrient artery of the medulla. It runs *towards* the elbow like that in the radius. Lower down is the origin of the ‘*pronator quadratus*.’ The back part of the shaft is marked by ridges and surfaces for the muscles, as follows:—Near the elbow is the triangular surface for the insertion of the ‘*anconeus*;’ next comes the ridge for the origin of the ‘*supinator radii brevis*’: observe that this muscle also arises from the depression just below the lesser sigmoid cavity. Below the supinator brevis arise in succession part of the ‘*extensor ossis metacarpi pollicis*,’ of the ‘*extensor secundi internodii pollicis*,’ and also the ‘*indicator*.’*

Of the three edges of the shaft, the *internal* gives attachment to the interosseous membrane; the *anterior* is covered by the origin of the ‘*flexor profundus digitorum*’; the *posterior* gives origin to a strong aponeurosis, which not only covers the muscles on the inner side of the fore-arm, but also affords additional surface for the origin of the ‘*flexor carpi ulnaris*,’ the ‘*flexor digitorum profundus*,’ and the ‘*extensor carpi ulnaris*.’ The posterior edge (or ridge of the ulna, as it is generally called) deserves the more notice, because it is subcutaneous, and can be traced all the way down; so that, in a doubtful fracture, this is the proper place to feel for it. Before reaching the elbow the ridge

* It is not uncommon to find that some of the fibres of the ‘*extensor primi internodii pollicis*’ arise from the ulna.

bifurcates, and encloses a triangular space, which is also subcutaneous: here we feel for fractures of the olecranon.

LOWER END.

The lower end of the ulna is termed its 'head.'

It forms a fulcrum upon which the semilunar cavity in the radius rolls. For this purpose it has, on one side, a convex surface, forming rather more than half a circle, round which the radius, and with it the hand, can rotate to the same extent. It has also another articular surface, lined with a synovial membrane, which looks towards the wrist joint, and corresponds with the interarticular fibro-cartilage interposed between it and the cuneiform bone of the wrist. Observe that the ulna does not reach down quite so low as the radius, though this fibro-cartilage partly fills up the interval. The reason why the ulna does not descend so low as the radius is, to allow more extensive horizontal movement of the wrist towards the ulnar side of the fore-arm.

The *styloid* process projects from the lower end of the *back* part of the ulna, that it may not interfere with the rotation of the radius, and gives attachment to the internal lateral ligament of the wrist. Between the process and the head there is a groove on the posterior aspect of the bone for the passage of the tendon of the 'extensor carpi ulnaris' (Plate XXXVI.); and inferiorly, the process is separated from the head by a depression for the attachment of the triangular fibro-cartilage of the wrist.

The styloid processes of the radius and ulna can be readily felt beneath the skin, and are important guides in the determination of injuries of the wrist, whether fracture of the radius or dislocation. The relative position of the styloid processes with regard to the axis of motion at the wrist will settle the question.

OSSIFICATION.

The ulna has three centres of ossification,—one for the shaft and coronoid process, one for the lower end, and a third for the olecranon. The lower end begins to ossify about the fifth year, and unites to the shaft about the twentieth. The top of the olecranon remains cartilaginous until the age of eight, about which time it begins to ossify: it coalesces with the base about puberty.

BONES OF THE HAND.

(PLATES XXXIV. XXXV. XXXVI.)

THE skeleton of the hand consists of twenty-seven bones. The first eight are the little bones of the carpus; the five succeeding bones constitute the metacarpus: these support the bones of the fingers. Each finger has three bones, termed, in order from the wrist, the first, second, and third or ungual phalanx. The thumb has only two phalanges,—namely, the first, and the third or ungual.

THE CARPUS.

(PLATE XXXVI.)

NUMBER AND
NAMES.

The carpus consists of eight little bones, arranged transversely in two rows of four each, so as to form a broad base for the support of the hand. It is sometimes asked, Why are there so many bones in the wrist? The answer is, that there may be so many joints: for the structure of a joint not only permits motion, but confers elasticity. Remember that each articular surface is crusted with cartilage to prevent jarring. Suppose there had been a single bone instead of the eight carpal bones, how much more liable it would have been to fracture and dislocation. As it is, dislocation of one or more bones of the carpal range is a rare occurrence; but it does happen sometimes. Sir C. Bell tells us that ‘the boy that played the dragon in the pantomime at Covent Garden, fell upon his hands, owing to the breaking of the wire that suspended him, and he suffered dislocation of some of the carpal bones in both hands.’ The bones of the carpus are named as follow, beginning from the radial side:—

FIRST ROW	• ‘SCAPHOID,’ ‘SEMILUNAR,’ ‘CUNEIFORM,’ ‘PISIFORM.’
SECOND ROW	• ‘TRAPEZIUM,’ ‘TRAPEZOID,’ ‘OS MAGNUM,’ ‘UNCIFORM.’

A minute separate description of each of these bones would be exceedingly tedious. We hope to bring out a better idea of their general shape and arrangement by examining them, at first, collectively. For this purpose it is very desirable that the student should have before him an articulated hand, as well as the separate bones.

CARPAL ARCH.

As a whole, the outline of the carpus is oblong, with the broad diameter in the transverse direction. Its bones are wedged together so as to form an arch with the concavity towards the palm, beautifully adapted for the passage of the flexor tendons of the fingers. Fig. 3 in Plate LVI. shows that the piers of the arch are formed on one side by projections from the scaphoid and trapezium; on the other, by the pisiform and the hook of the unciform. The arch is converted into a complete tunnel by the anterior annular ligament.

RADIO-CARPAL JOINT.

Let us begin with the bones of the first row. Excluding the pisiform, which is only an 'outstanding 'sesamoid' bone, we observe that the scaphoid, semilunar and cuneiform bones form a convex articular surface, which, with the lower end of the bones of the fore-arm, forms the radio-carpal joint. This joint is formed so as to admit, not only of the movement of flexion and extension, but also of the horizontal movement of the wrist (abduction and adduction). We observe also that the upper articular surfaces of the first row are prolonged further down their dorsal than their palmar aspect: hence the free movement of extension at the wrist. Looking at the articular surfaces of the individual bones, we observe that those of the scaphoid and semilunar fit into the radius; while that of the cuneiform, which is the least extensive of the three, corresponds with the ulna, not *immediately*, but by means of the triangular fibro-cartilage attached in the recent state to the lower end of the ulna. The bones of the first row articulate with each other by plane surfaces crusted with cartilage, but they are so firmly connected by ligaments that there is very little movement between them.

INTERCARPAL JOINT.

Collectively, the lower ends of the first row form, with the bones of the second row, an important movable joint, which we call the 'intercarpal.' It is very

different in form from the first joint (radio-carpal) of the wrist, since its outline is alternately convex and concave. Now the advantage obtained by this second joint is, that we get a greater range of flexion and extension at the wrist. If there had been only a single joint for this amount of motion, it would have been comparatively insecure, and very liable to dislocation, whereas dislocation of the wrist happens very rarely indeed. By reference to Plate XXXVI. it is seen that the lower part of the scaphoid has a *convex* articular surface which corresponds with the trapezium and trapezoid, and also a *concave* one, which, with a concavity in the semilunar and cuneiform bones, forms a deep socket fitted to receive the head of the os magnum and the unciform.

ARTICULATIONS
OF FIRST ROW.

We observe, also, that the scaphoid articulates with five bones inclusive of the radius; the semilunar with five inclusive of the radius; the cuneiform with four inclusive of the ulna; and the pisiform with one, namely, the cuneiform.

Sc. Sl. Cu
5 3 4 1

In consequence of the flexors and extensors of the wrist being inserted below the second row of carpal bones, they necessarily act on the 'intercarpal joint' as well as the radio-carpal. Thus a greater amount of motion is provided at the wrist than it otherwise could have possessed with safety. If such free motion had been given to one joint, the angle of flexion must have been great and the ligaments looser than would have been consistent with the security of the joint.

BONES OF THE
SECOND ROW.

With respect to the upper ends of the bones of the second row, we observe that the trapezium and trapezoid form a shallow socket for part of the scaphoid, while the os magnum and unciform form a convexity, which fits into the deep socket formed by the scaphoid, semilunar, and cuneiform in the first row. Below, the second row supports the metacarpal bones, as follows: The trapezium supports the metacarpal bone of the thumb by a concavo-convex, or saddle-shaped surface; the trapezoid supports that of the fore-finger; the os magnum that of the middle finger; and the unciform those of the ring and little

fingers. But this is not all. Observe that the trapezium supports, also, part of the second metacarpal bone; and the os magnum, also, part of the second and the fourth. The consequence is, that the metacarpal bones present different degrees of mobility,—that of the thumb being the most movable, those of the fore and middle fingers the least.

ARTICULATIONS OF SECOND ROW.

Like the bones of the first row, those of the second articulate with each other by plane surfaces firmly connected by ligaments. The trapezium articulates with four bones; the trapezoid with four; the os magnum with seven; the unciform with five.

DISTINCTION OF INDIVIDUAL BONES.

Thus far we have examined the bones of the carpus collectively; how are we to distinguish them individually? Whoever remembers what has been already said, will not have much difficulty in recognising the separate bones; but it requires some practice before one can pronounce to which hand a given bone belongs.

SCAPHOID BONE.

The 'scaphoid' bone may be told by its boat-shaped socket ($\sigma\kappa\acute{\alpha}\phi\eta$, a boat), by its long narrow groove* on the dorsal aspect between its two convex surfaces, and by its 'tubercle' for the attachment of the ligaments of the wrist (anterior annular and external lateral).

RIGHT OR LEFT?

Hold the bone horizontally, with the largest convex surface looking upwards, and the groove towards yourself: the tubercle will point to which hand the bone belongs.

SEMILUNAR BONE.

The 'semilunar' bone may be told by its two 'semilunes' below (whence the name): the larger and external being for the os magnum, the lesser and internal for the unciform.

RIGHT OR LEFT?

Hold the bone with its smooth convex surface upwards, its broader (or palmar) *non-articular* surface forwards, and the semilunes downwards, resting on your finger; the bone will slant downwards towards the side to which it belongs.

* This groove is for the insertion of the posterior radio-carpal ligament.

CUNEIFORM
BONE.

The 'cuneiform' bone may be told by its little round articular surface for the pisiform bone, and its concavo-convex surface below for the unciform.

RIGHT OR LEFT?

Hold the bone with its concavo-convex surface downwards, and its round surface for the pisiform looking forwards; the broader end will be on the side to which the bone belongs.

PISIFORM BONE.

The 'pisiform' bone may be told by its pea-shape (whence its name); and by its single concave articular surface for the cuneiform.

RIGHT OR LEFT?

Hold the bone with the articular surface upwards, and the large overhanging projection forwards (which is the natural position with the hand prone); a slight furrow (fig. 33, *a*) close to the articular surface will be on the side to which the bone belongs. (It is often difficult to determine with certainty to which side this bone belongs. The furrow alluded to is generally sharply marked, deep, and narrow; be careful not to confound it with the wide and shallow groove often seen on the opposite or outer side of the articular surface.)

FIG. 33.

RIGHT PISI-
FORM, SLIGHTLY
ENLARGED.

TRAPEZIUM.

The 'trapezium' (so named from its shape) may be told by its saddle-shaped articular surface for the metacarpal bone of the thumb; by the deep groove for the tendon of the 'flexor carpi radialis,' and the prominent ridge on the outer side of that groove for the attachment of the anterior annular ligament, and the origin of the 'opponens' and 'abductor pollicis.'

Hold the bone with the groove upwards and in the antero-posterior direction, but with the prominent ridge nearest to you, the saddle-shaped surface (for the first metacarpal bone) will point to the side to which the bone belongs.

TRAPEZOID
BONE.

The 'trapezoid' bone (so named from its shape) may be told by its four articular surfaces and four angles.

RIGHT OR LEFT?

Hold the bone with the large non-articular (dorsal) surface backwards, and the palmar sur-

face forwards, with its narrowest side uppermost; then the corner of the palmar surface which appears sliced off will be on the side to which the bone belongs.

OS MAGNUM.

The 'os magnum' is the largest and most important of all the carpal bones. It forms the 'median axis' of the hand, and articulates with seven bones. Its large round 'head' forms the ball for the socket in the scaphoid and semilunar above. Its outer border articulates with the trapezoid; its inner with the unciform; its lower with the third metacarpal bone chiefly, and also with the second and fourth. Its posterior dorsal surface is flat and rough: its anterior bulges a little forwards.

RIGHT OR LEFT?

Hold the bone with the head up, and dorsal surface towards you: the largest surface of the round head will be towards the thumb of the hand to which it belongs.

UNCIFORM BONE.

The 'unciform' bone may be told by its remarkable hook-like process; whence its name.

RIGHT OR LEFT?

Hold the bone with the unciform process downwards, and the articular surface with the two facets (for the fourth and fifth metacarpals) directed forwards. The convexity of the process will look towards the hand to which it belongs.

MUSCLES ATTACHED TO THE CARPAL BONES.

No muscles are connected with the dorsal surface of the carpus. On the palmar aspect the pisiform gives insertion to the 'flexor carpi ulnaris,' and origin to the 'abductor minimi digiti.' The trapezium gives origin by its 'ridge' to the 'opponens pollicis,' to part of the 'abductor,' and of the outer head of the 'flexor brevis pollicis.' The trapezoid and os magnum to the 'flexor brevis pollicis.' The unciform gives origin by its 'process' to the 'flexor brevis minimi digiti,' and to the 'opponens minimi digiti.'

OSSIFICATION OF THE CARPAL BONES.

The carpus is entirely cartilaginous at birth. Each bone ossifies from a single nucleus. The nucleus of the os magnum appears in the first year; that of the unciform in the second; that of the cuneiform in the third; those of the trapezium and semilunar in the fifth:

that of the scaphoid in the eighth; that of the trapezoid in the ninth; that of the pisiform in the twelfth. This is the last bone in the body to ossify.

THE METACARPUS.

(PLATES XXXIV., XXXV.)

The metacarpus consists of the five bones which support the phalanges of the thumb and fingers. We speak of them as the first, second, third, etc., counting from that of the thumb. Considering them as 'long bones,' which they very much resemble in their general structure, we speak of their shafts and their two ends; the upper end being termed the 'base,' the lower, the 'head' of the bone.

SHAFTS. The 'shafts' are slightly concave towards the palm, to form the hollow of the hand. They are more or less triangular, being made so by the impressions of the 'interosseous' muscles which occupy the 'interosseous spaces.' The apex of the triangle is on the palmar surface, the base on the dorsal surface for the convenient support of the extensor tendons of the fingers.

BASES OR UPPER ENDS. Their 'bases' articulate not only with the bones of the carpus, but, by 'lateral facets,' with each other: that of the thumb, however, stands out alone, so as to oppose all the others. It is one of the great characteristics of the hand of man, that the point of the thumb can touch with perfect ease the tips of all the fingers.

HEADS. The lower ends or 'heads' have convex surfaces for articulation with the first phalanges of the fingers. These surfaces extend chiefly towards the palm. They allow the fingers not only to be bent and extended, but to be moved laterally. On each side of their heads is a projection for the attachment of the lateral ligaments.

The shaft of each metacarpal bone has a canal for the nutrient artery of the medulla. In the second, third, fourth, and fifth

metacarpal bones, the direction of this canal is upwards; but in the metacarpal bone of the thumb its direction is downwards. This is in accordance with the law which regulates the union of the epiphyses (p. 25).

METACARPAL
BONE OF THE
THUMB.

Besides which, its shaft is shorter, broader, and stronger

FIG. 34.

1.



BASE OF FIRST
RIGHT META-
CARPAL, OUTER
SIDE.

The metacarpal bone of the thumb is distinguished by the characteristic saddle-shaped surface at the base, which articulates with the trapezium. There are no less than nine muscles to work the thumb. Observe that the great mobility in all directions of the thumb, so essential to the power and perfection of the human hand, depends upon this saddle-shaped joint at its base; and that its power of antagonising the fingers is owing to its base being set off on a plane anterior to them.* On the palmar aspect of its head, observe two smooth surfaces occasioned by the play of the outer and inner sesamoid bones which are connected with the tendons of insertion of the 'flexor brevis pollicis.'

Hold the bone with the base towards you, and the dorsal surface uppermost. The base will incline slightly towards the side to which it belongs. The impression on one side of the base (indicating the insertion of the extensor ossis metacarpi pollicis) will look away from the side to which the bone belongs (see fig. 34).

* Sir Charles Bell, in his work on the Hand, says: 'It is upon the length, strength, free lateral motion, and perfect mobility of the thumb that the superiority of the human hand depends.' He might have pointed out by what a simple contrivance nature provides for this perfect mobility. It is this. 'The saddle-shaped surface by which the trapezium articulates with the metacarpal bone of the thumb, instead of looking directly forward, is made to incline outwards by a little buttress of bone which projects from the inner and front part of the trapezium. This buttress answers yet another purpose. It articulates with the firmly fixed metacarpal of the fore-finger. But for this contrivance, the thumb would fall into the same line as the fingers, and would not possess that power of opposing them which makes the human hand such a wonderful instrument.' The preceding observation was made by Mr. J. Lockwood, a student at St. Bartholomew's Hospital.

METACARPAL OF
FORE-FINGER.

The metacarpal bone of the fore-finger is distinguished by its deeply indented surface at the base, which is immovably wedged with three of the carpal bones; also by having a 'lateral facet' on the inner side for the third metacarpal.

RIGHT OR LEFT?

Hold the bone with the base towards you and the dorsal surface upwards; the lateral facet will be on the side to which the bone belongs. See fig. 35.

METACARPAL OF
MIDDLE FINGER.

The metacarpal bone of the middle finger may be known by its having a smooth square surface at the base for the os magnum, and an angular projection at the corner of it for the insertion of the 'extensor carpi radialis brevior.' It has also 'lateral facets' on each side. Sometimes, as seen in fig. 36, the inner facet is divided into two.

RIGHT OR LEFT?

With the base towards you and the dorsal surface uppermost, the corner of the base which has no projection will be on the side to which the bone belongs.

METACARPAL OF
RING FINGER.

The metacarpal bone of the ring finger articulates with the unciform and part of the os magnum. It may be distinguished by its smaller size; by the absence of the angular projection at the base, which is flat, and by its having two facets on the outer side and one on the inner (figs, 38, 39).

RIGHT OR LEFT?

With the base towards you and the dorsal surface uppermost, the base has a slight inclination towards the side it belongs to.

FIG. 35.
II.BASE OF
SECOND RIGHT
METACARPAL,
INNER SIDE.FIG. 36.
III.

INNER SIDE.

FIG. 37.
III.

OUTER SIDE.

BASE OF THE THIRD RIGHT
METACARPAL.FIG. 38.
IV.

INNER SIDE.

FIG. 39.
IV.

OUTER SIDE.

BASE OF FOURTH RIGHT
METACARPAL.

FIG. 40.

V.



FIG. 41.

V.



OUTER SIDE. INNER SIDE.

BASE OF FIFTH RIGHT
METACARPAL.METACARPAL OF
LITTLE FINGER.

The metacarpal bone of the little finger may be recognised by its concavo-convex surface at the base to articulate with the unciform bone, and by its having only one lateral facet, namely, on the outer side (fig. 40). The projection on the inner side of the base is for the 'extensor carpi ulnaris.'

RIGHT OR LEFT?

With the base towards you and the dorsal face uppermost, the projection from the side of the base will be on the side to which the bone belongs.

OSSIFICATION OF
METACARPAL
BONES.

As a general rule, each metacarpal bone has a centre of ossification for the shaft and upper end, which appears about the eighth week. Each also has an epiphysis at its lower end, of which the nucleus appears about the fourth year. The metacarpal bone of the thumb, however, has its epiphysis at the upper end, like the phalanges of the fingers. All unite to the shafts about the twentieth year.

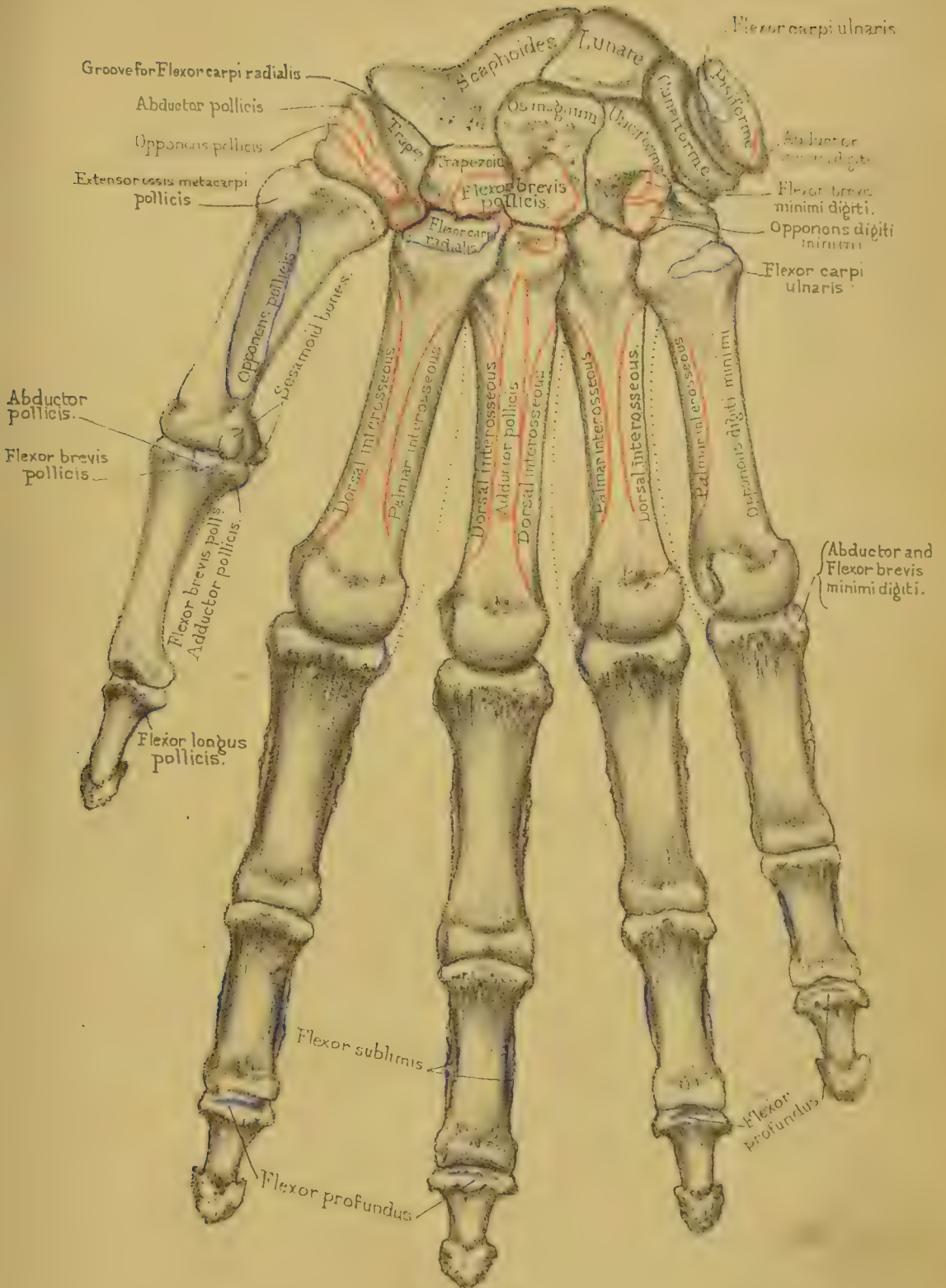
To the rule above stated there are certainly exceptions. I have seen preparations clearly showing separate epiphyses at the *upper* ends of the metacarpal bones of the fore and middle fingers. I have also seen a separate epiphysis at the *lower* end of the metacarpal bone of the thumb. Whether these additional epiphyses be normal or exceptional, they always unite the first to the shaft, in accordance with the direction of the artery of the marrow, which in the metacarpal of the thumb runs towards the lower end, in those of the fingers towards the upper.

THE BONES OF THE FINGERS.

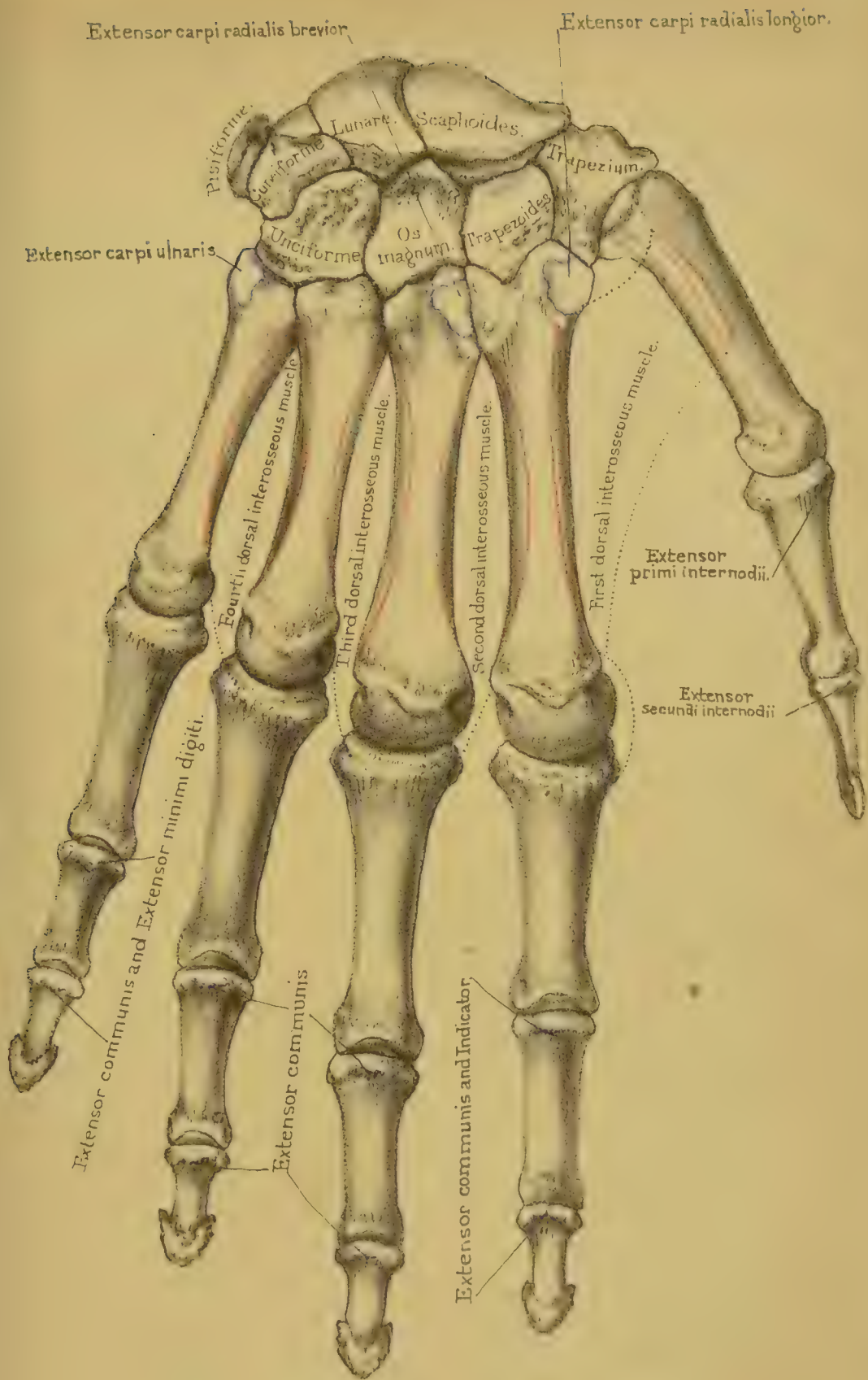
(PLATE XXXIV.)

GENERAL
DESCRIPTION.

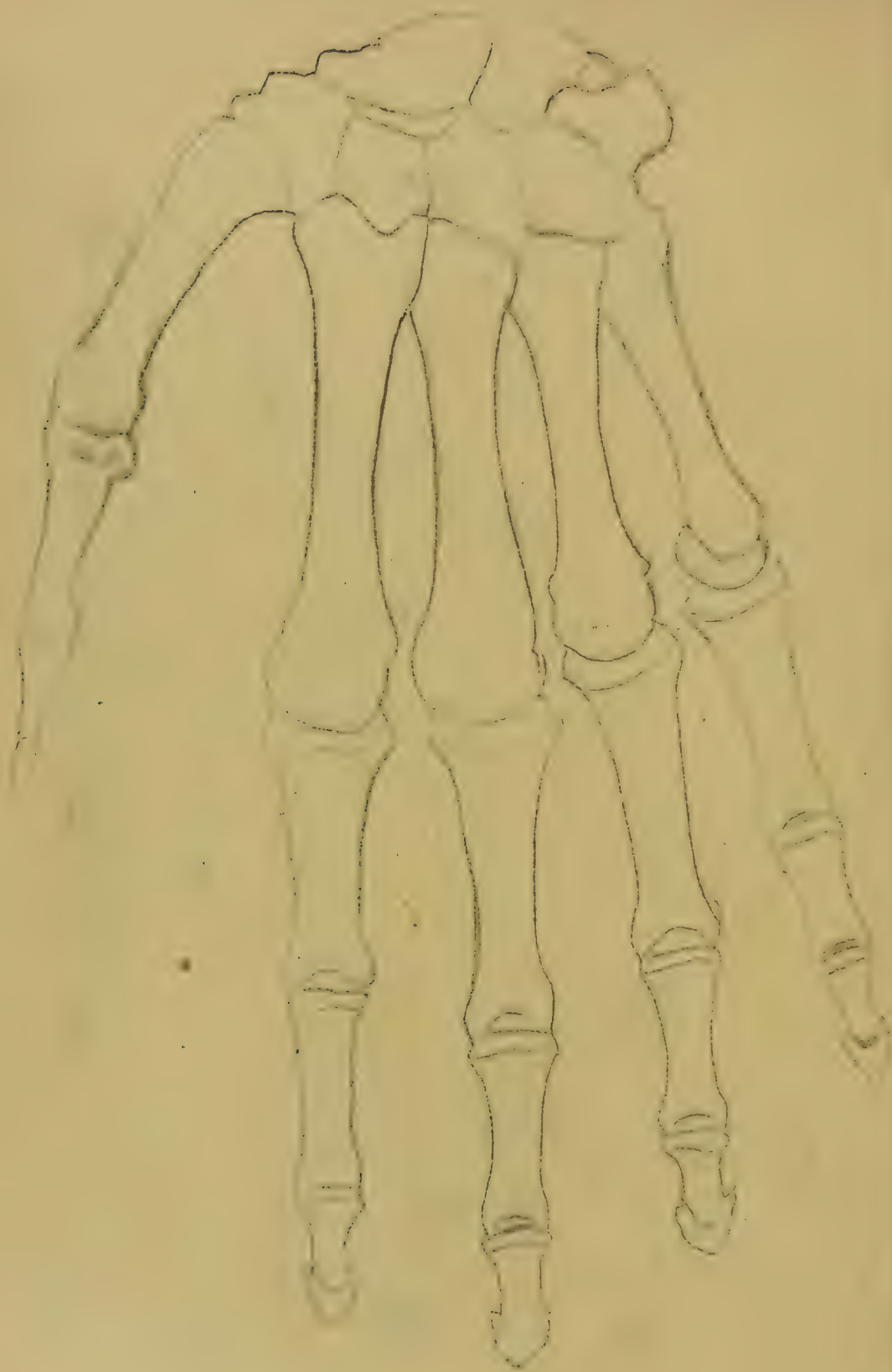
Each finger consists of three bones, successively decreasing in size, and termed respectively the first, second, and last or ungual 'phalanges.' The thumb has only



Palmar surface.

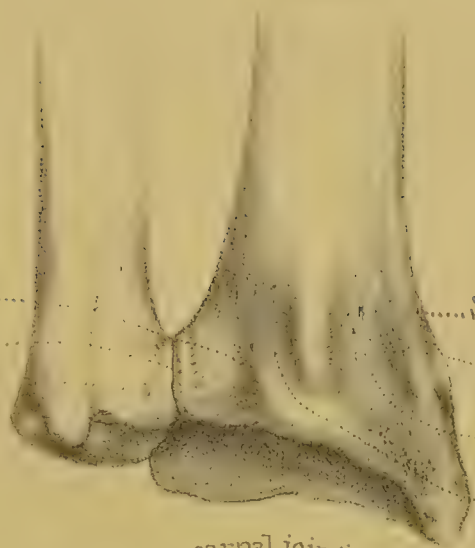


Dorsal surface



Ulna.

Radius.



Extensor indicis }
Ext. comm. digiti }
Ext. minimi digiti }
Ext. carpi ulnaris

..... Supinator radii longus.
(Ext. ossis metacarpii pollicis
(Ext. primi internodii pollicis.
Ext. carpi radialis.
longior et brevior.
Ext. secundi internodii pollicis

Radio-carpal joint



Inter-carpal joint.



View of the intercarpal joint.



two phalanges, and these correspond to the first and last of those of the fingers. A general description will suffice for all.

The structure of each phalanx is precisely like that of the great long bones, and a longitudinal section through one of them would display the great thickness of the compact wall of the shaft.

Considering the phalanges as 'long' bones, we speak of their shafts and their articular ends. The shafts are convex on the dorsal surface, and flat on the palmar, for the convenient play of the flexor tendons: and here observe, that on each side of this flat surface there is a ridge for the attachment of the fibrous sheath (theca), which keeps the tendons in their place.

FIRST PHALANGES. The first phalanges are distinguished by their greater length, and by the shape of their upper (metacarpal) ends, which do not form strictly hinge-joints, but have concave oval surfaces, with the long diameters transverse, adapted for lateral movement as well as flexion on the heads of the metacarpal bones. In accordance with this lateral movement, we observe, on each side, a tubercle for the insertion of the interosseous muscles which produce it. Their distal ends are divided by a shallow groove into two little condyles with lateral tubercles for the ligaments.

SECOND PHALANGES. The second phalanges are shorter than the first, and are recognised by the shape of their upper ends, which have two little concave surfaces, with an intervening ridge, so as to form a hinge with the little condyles of the first phalanges. They have also tubercles behind for the insertion of the extensor tendons.

THIRD PHALANGES. The last or ungual phalanges are the shortest. Their ends expand into a horse-shoe shape, smooth on one surface for the support of the nails, and rough on the other for the support of the pulp of the fingers.

FINGERS. WHY UNEQUAL IN LENGTH? It has been asked, Why are not the fingers of equal length? Close them upon the palm and then see whether or not they correspond. This difference in the length of the fingers serves a thousand purposes, to which the works of human art and industry bear ample testimony.

It may, perhaps, be interesting to some persons to know that the 'middle digit' is the most constant of all the digits in the vertebrate series. Few are aware that the bones forming the three joints of this finger answer to those called 'great pastern bone,' 'little pastern bone,' and 'coffin bone' in the horse; and that the nail in this finger represents the hoof.

OSSIFICATION OF THE PHALANGES. Each phalanx has two centres of ossification; one for the shaft and the lower end; the other for the upper end, which remains an epiphysis till about the twentieth year.

SESAMOID BONES.

(PLATE XXXIV.)

POSITION AND USE. These little bones are so called from their resemblance in size and shape to the grain '*sesamum*.' They are met with in the substance of tendons in the neighbourhood of joints,—the 'patella,' or 'knee-pan,' being the best example. Their use is to increase the leverage of the tendons. The thumb has two of these bones beneath its metacarpal joint, to increase the leverage of the 'flexor brevis pollicis.' We rarely find any for the fingers.

Of all animals, the mole has the most remarkable apparatus of 'sesamoid' bones. Its prodigiously strong digging feet are richly provided with them, in order to increase the leverage of the brachial muscles, which enable the animal, as it were, to swim through the earth.

INTEROSSEOUS MUSCLES.

NUMBER AND ARRANGEMENT. There are eight interosseous muscles: four on the dorsal aspect, and four* on the palmar aspect of the hand. The *dorsal* interossei arise from the opposite sides of the metacarpal bones, and are inserted into the first phalanges of the fingers, so that they separate the fingers from each other; in other words, they draw the fingers *from* a stationary line supposed to pass down the centre of the middle finger, as represented by the dotted line in fig. 42.

* Counting the adductor pollicis as an interosseous muscle.

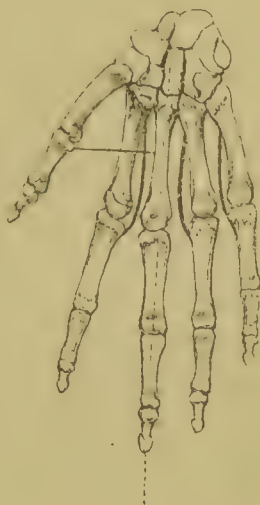
The *palmar* interossei arise each from one metacarpal bone, and are inserted into the fingers, so that they bring them together ; in

FIG. 42.



FOUR DORSAL INTEROSSEI
DRAWING FROM THE MIDDLE LINE.

FIG. 43.



FOUR PALMAR INTEROSSEI
DRAWING TOWARDS THE MIDDLE LINE.

fact, they draw *towards* the stationary line down the centre of the middle finger, as shown in fig. 43.

C S H U R
/ 15 2 3 3

BONES OF THE LOWER EXTREMITY.

CONSTITUENT BONES. THE bones of the lower extremity consist of the 'femur,' the 'patella,' the two bones of the leg, namely, the 'tibia' and 'fibula,' the bones of the 'tarsus,' the 'metatarsus,' and the 'phalanges' of the toes.

The femur articulates with the pelvis. Now the pelvis itself is composed of several bones,—namely, the 'os sacrum,' the 'coccyx,' or terminal piece of the spine, and the two 'ossa innominata,' one on each side. These several bones are wedged together, so as to form an arch. The weight of the spine is supported by the sacrum, or key-stone of the arch; and the weight of the trunk is transmitted from the sides of the arch on to the thigh bones. We must therefore study—first, the constituent bones of the pelvis, beginning with the 'os innominatum;' secondly, the pelvis as a whole.

OS INNOMINATUM.

(PLATE XXXVII.)

GENERAL DESCRIPTION. DIVISION INTO ILIUM, ISCHIUM, AND PUBES.

The 'os innominatum,' so named by Galen, is made up of three bones, distinct in childhood, but united in the adult, and termed the 'ilium,' 'ischium,' and 'pubes.' Thus its constituents have received appropriate names, but the bone, consolidated, remains 'nameless.' The 'ilium' is the expanded part which supports the flank (ilia); the 'ischium' supports the body in the sitting posture (*ἰσχύια*, the buttocks); the 'pubes' is the front part—so called from its being covered with hair. All three contribute to form the 'acetabulum,' or socket for the head of the

femur, and in the following proportions (fig. 3):—the ischium contributes rather more than two-fifths, the ilium rather less than two-fifths, and the pubes about one-fifth. Until the age of puberty they are separated at the bottom of the acetabulum by a piece of cartilage shaped like the letter Y. In the adult, however, little trace is left of the original division, so that, for practical purposes, it is better to consider the bone as *one*, and to describe successively its iliac, pubic, and ischial portions.

In studying the relative bearings of these several parts in the erect position of the body, it is necessary that the bone be held at such an inclination that the ‘notch’ in the margin of the acetabulum directly faces the ground.

The ‘ilium’ (os ilii) forms a broad expanse for the support of the abdominal viscera, and gives a powerful leverage to the great muscles which balance the pelvis on the head of the femur. We must examine its outer and inner surfaces, and its borders.

OUTER SURFACE OF THE ILIUM. The outer surface of the ilium (dorsum ilii) is slightly undulating, being convex on its anterior half, and concave on its posterior. In a well-marked bone, we discern the traces, termed the ‘superior and inferior curved lines,’ which map out the origins of the gluteal muscles. These lines commence, the one at the ‘anterior superior spine,’ the other at the ‘anterior inferior spine,’ and extend backwards to the ‘greater ischiatic notch.’ The surface above the superior line gives origin to the ‘gluteus medius’; that between the lines to the ‘gluteus minimus.’ A rough surface further back indicates the origin of a part of the ‘gluteus maximus.’* Just above the acetabulum is the second origin of the ‘rectus’ (femoris), the first being at the ‘anterior inferior spine.’

INNER SURFACE: ILIAC FOSSA. The inner surface of the ilium is slightly excavated, so as to form the ‘iliac fossa.’ This fossa is one of the characteristics of the human skeleton, and its use

* The ridge between the origin of the gluteus medius and the iliac origin of the gluteus maximus is called the ‘superior curved line’ by some anatomists; then, our ‘superior’ is their ‘middle.’ Authors differ about the names of these ‘lines,’ but agree about their existence.

is to support the abdominal viscera. It gives origin to the 'iliacus internus.' Hold the bone to the light, and observe that the bottom of the fossa is the thinnest part of the ilium, for the good reason, that it is out of the line of the weight of the body. The fossa is bounded below by the 'linea ilio-pectinea,' which forms the true '*brim of the pelvis.*' This brim is the thickest and strongest part of the bone, since it is the 'line of the pelvic arch,' along which the weight of the trunk is transmitted to the head of the thigh bone. No one can form an adequate idea of the massive architecture of this part of the pelvis without inspecting a longitudinal section such as we have shown in Plate XII. But we must postpone for the present the mechanism of this beautiful arch. Behind the iliac fossa is the articular surface for the sacrum (sacro-iliac symphysis). The front part of this is shaped like a little ear, and, in the recent state, crusted with cartilage, which acts as a 'buffer' to the joint, while the hinder part is exceedingly rocky for the attachment of the strong 'interosseous' ligament which secures it. Lastly, on the inner surface is the large foramen, which transmits nutrient blood-vessels and a nerve into the cancellous texture.

CREST AND
SPINES OF THE
ILIUM.

The upper border of the ilium is termed the 'crest.' Looking at it from above, we observe that its outline is alternately concave and convex, like the adjoining figure (44), in adaptation to the general surface of the ilium, which undulates at the one part to form the 'iliac fossa' (i), and at the other, to form what may be termed the 'gluteal fossa' (g), for the convenient lodgment of the muscles of the buttock. The crest is rough and broad, and is spoken of in the 'schools' as presenting three 'lips'—an 'outer,' an 'inner,' and a 'middle,'—for the origin of the muscles which form the lateral walls of the abdomen. The 'outer lip' gives origin* to the 'tensor fasciæ femoris,' the 'obliquus externus abdominis' and the 'latissimus dorsi'; the middle lip gives origin to the 'obliquus internus'; and the inner lip to the



CURVES OF
RIGHT ILIUM.

* This is by some considered as an 'insertion.' It is an open question, of which the answer depends upon the varying actions of the muscle.

‘transversalis abdominis,’ the ‘quadratus lumborum,’ and a part of the ‘erector spinæ.’

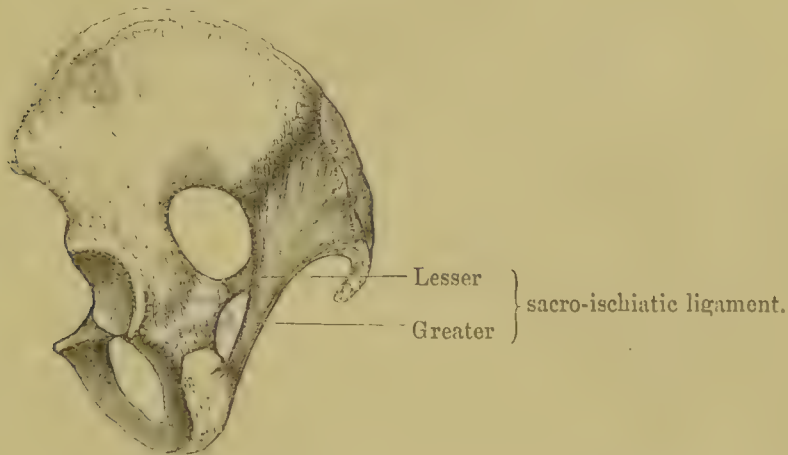
ANTERIOR
SPINES.

Along the front border of the ilium we have to notice the ‘anterior-superior’ and ‘anterior-inferior spines,’ with the shallow notch between them. The superior spine, and the edge of the notch below, give origin to the ‘sartorius,’ and the inferior spine to one head of the rectus. Below this spine is another notch, for the passage of the iliacus and psoas muscles, and then comes the ‘ilio-pectineal eminence,’ where the ilium and pubes join. This eminence is interesting, practically, as the part over which the femoral artery passes into the thigh, and against which it can be effectually compressed.

POSTERIOR
SPINES AND ISCHI-
ATIC NOTCHES.

Along the posterior border of the ilium are the ‘posterior-superior’ and ‘posterior-inferior spines,’ with the little notch between them. These spines are for the attachment of ligaments. Below the spines is the ‘greater ischiatic notch,’ which transmits the great vessels and nerves from the pelvis to the buttock and back of the thigh. Lower still is

FIG. 45.



the ‘spine of the ischium,’ and then we come to the ‘lesser ischiatic notch.’ In the recent state the notches are converted into complete holes by the ‘sacro-ischiatic ligaments,’ greater and lesser respectively, as shown in the cut, fig. 45. These ligaments answer three important purposes: 1. They mainly contribute to the fixation of the sacrum, which is the keystone of the pelvic

arch; 2. They afford an extensive surface for the origin of the great muscle of the buttock (*gluteus maximus*); 3. They help to form the floor of the pelvis, and support the pelvic viscera, without adding much to the weight of the cavity. Returning to the notches, bear in mind the several objects which pass through them. These objects are as follows:—

The GREATER ISCHIATIC NOTCH transmits	{	Gluteal vessels and nerve.
		Pyriformis muscle.
		Greater and lesser ischiatic nerves.
		Ischiatic vessels.
		Pudic vessels and nerve (out of pelvis).
The LESSER ISCHIATIC NOTCH transmits	{	Nerve to obturator internus (out of pelvis).
		Tendon of the obturator internus.
		Nerve to obturator internus (into pelvis).
		Pudic vessels and nerve (into pelvis).

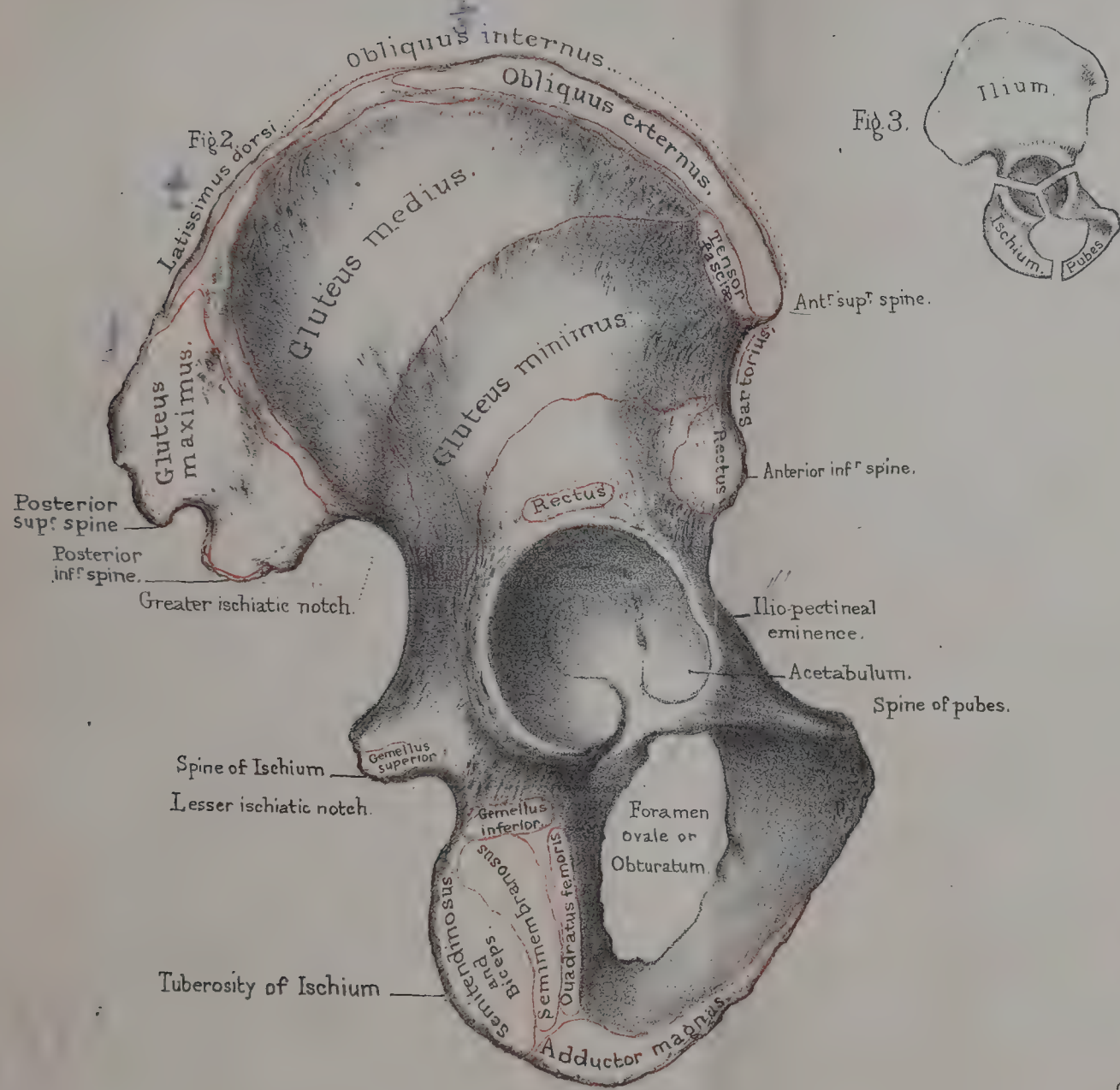
PUBES, BODY,
AND RAMI. The ‘pubes’ (Plate XL. fig. 1) is usually described as having a ‘body’ and two branches: one of which, called the ‘horizontal ramus,’ joins the ilium at the iliopectineal eminence; the other, called the ‘descending ramus,’ joins the ascending ramus of the ischium. Here observe, that the terms ‘horizontal’ and ‘descending,’ as descriptive of the direction of the ‘rami,’ are likely to mislead. But they have crept into general use, and therefore we must use them. The error has arisen from the pelvis having been described as if it were horizontal, which it is not. Look at a properly articulated skeleton, or hold the pelvis inclined at its proper angle to the horizon, and you soon see that the pelvic rami run in a direction almost the reverse of that which is implied by their names.

The ‘horizontal ramus’ of the pubes is somewhat triangular. Its upper surface gives origin to the ‘pectineus,’ and is marked by the continuation of the true brim of the pelvis, or ‘*linea ilio-pectinea*,’ which gives insertion to the ‘*psoas parvus*’ when there is one, and also to that part of the ‘crural arch’ termed ‘Gimbernat’s ligament.’ The inner surface forms part of the wall of the true pelvis, while its lower surface bounds the obturator foramen, and is grooved for the passage of the obturator vessels and nerve.

PUBIC ARCH.

The ‘descending ramus’ of the pubes inclines outwards and backwards, and forms, with its fellow

OS INNOMINATUM.

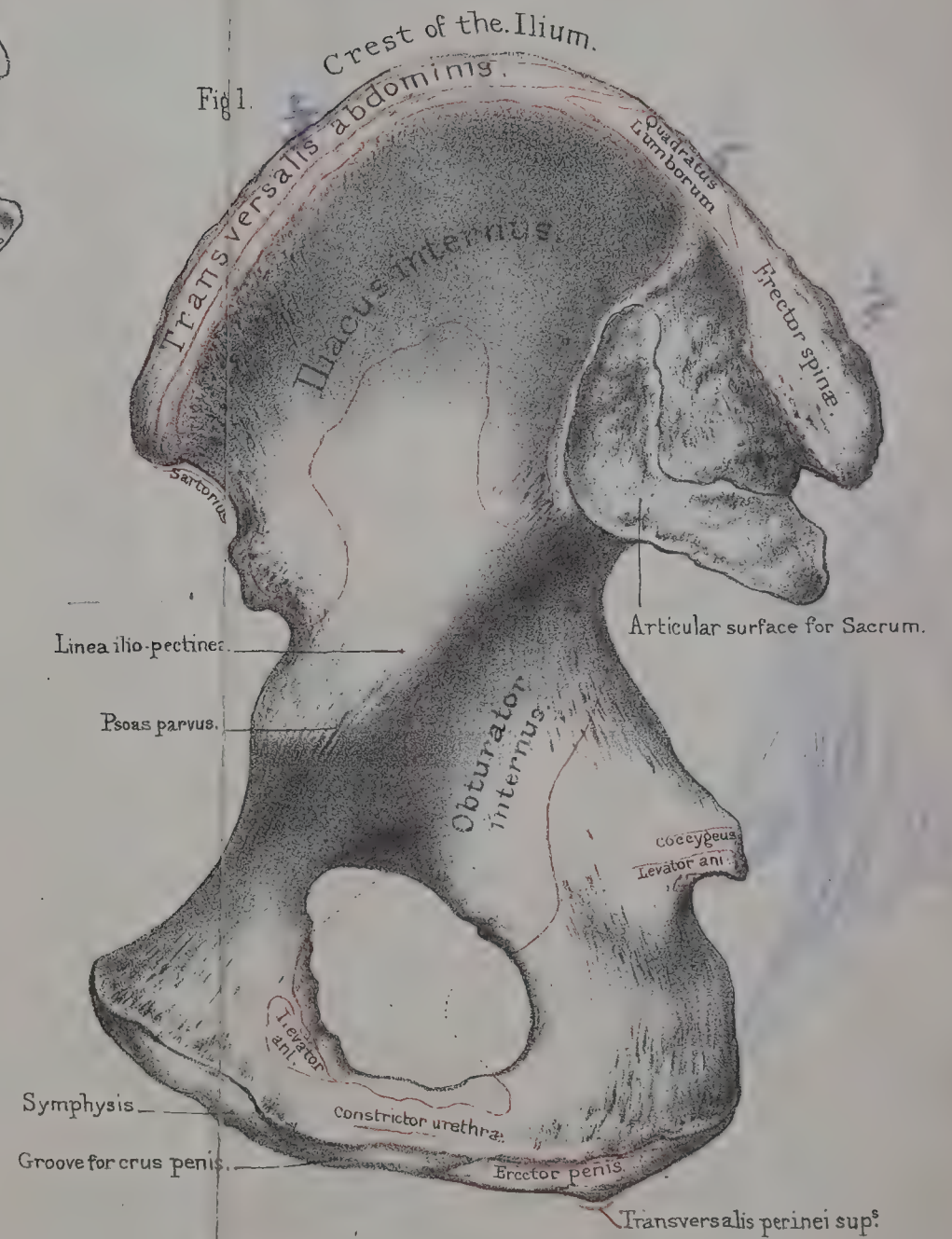


Outer surface

Fig. 3.



OS INNOMINATUM.



Inner surface.

Drawn on Stone by T. Godart

From nature by J. Haller.

Printed by W. West & Co.

of the opposite side, what is called the ‘arch of the pubes.’ The margin of the arch slopes a little outwards, and has a groove for the attachment of the ‘crus penis’ in the male, or ‘crus clitoridis’ in the female. This shelving of the arch is especially considerable in women, to facilitate the passage of the child. Behind the groove is the origin of the ‘constrictor urethræ.’

BODY AND SYM-
PHYSIS OF THE
PUBES.

The ‘body’ of the pubes (Plate XL.) is connected along a rough and somewhat oval surface to the answerable part on the opposite bone. This

union is termed the ‘symphysis pubis.’ Observe the bones are not here in immediate apposition, but united by fibro-cartilage of at least $\frac{3}{8}$ ths of an inch in thickness in front, which is elastic, like that between the bodies of the vertebræ, and, while it completes the pelvic arch below, serves also to obviate the effects of concussion. The summit of the pubes is a most important part in relation to the anatomy of hernia. *The chief point of interest here*

SPINE OF PUBES.

is the ‘spine.’ This is for the attachment of the ‘crural arch’ (Poupart’s ligament), and is, surgi-

cally, of great importance as the guide to the external abdominal and femoral rings. From the spine we trace outwards the beginning of the ‘linea ilio-pectinea,’ where ‘Gimbernat’s ligament’ is attached. Between the spine and the symphysis is the part called the ‘crest,’ with which so many muscles are connected. There are, namely, proceeding from the front, the insertion of the conjoined tendon of the ‘internal oblique’ and ‘transversalis,’ the origin of the ‘pyramidalis,’ and that of the ‘rectus abdominis.’ The posterior surface of the body forms part of the wall of the pelvic cavity; and you should observe that its angle of inclination, as well as that of the ‘symphysis,’ is such as to present (in the erect position) a gently sloping plane for the support of the pelvic viscera. Lastly, its anterior surface is rough for the origin of muscles; namely, the ‘adductor longus,’ ‘brevis,’ and part of the ‘magnus,’ also the ‘obturator externus’ and the ‘gracilis.’

ISCHIIUM, TUBE-
ROSITY, RAMUS, AND
SPINE.

The ischium completes the lower part of the innominate bone. (Plate XXXVII.) It serves to support the trunk in sitting, and projects advantageously for the origin of the hamstring muscles. If, in

imagination, we separate it from the rest of the bone, then we should point out a '*body*,' which is the most bulky part of it, for the formation of the acetabulum: from this, the bone drops vertically to form the '*tuberosity*' upon which we sit; and then, curving forwards like a hook, it forms the '*ascending ramus*,' which unites with the corresponding part of the pubes, and thus completes the '*foramen ovale*.' Leaving the acetabulum for separate study, we pass on to notice the '*spine of the ischium*,' which separates the '*greater*' from the '*lesser ischiatic notch*.' There is much to be said about this spine. Its outer side gives origin to the '*gemellus superior*'; its inner surface to the '*coccygeus*' and a part of the '*levator ani*': the front part of the '*levator ani*,' observe, arises from the body of the pubes, while the intermediate part arises from a tendinous arch thrown across from one point of bone to the other. Reverting to the spine, remember that the lesser sacro-ischiatic ligament is attached to it, and that the internal pudic artery crosses over its outer surface. In case of severe hæmorrhage after lithotomy, it would be possible in a thin subject to compress the artery against the bone.

FORAMEN OVALE,
OR OBTURATUM.

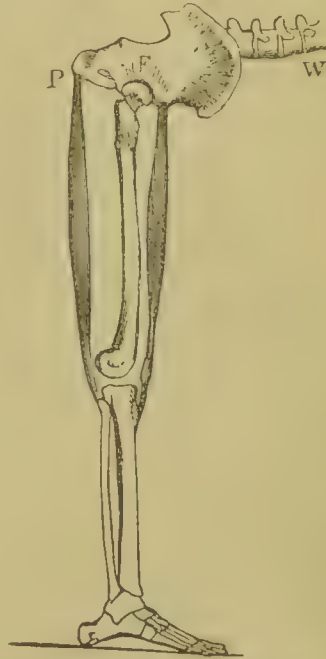
The '*foramen ovale*' or '*obturatum*,' sometimes called the '*thyroid foramen*,' is a wide opening of an oval form in the male, but triangular, with rounded angles, in the female. It is closed in the recent state by the '*obturator membrane*,' everywhere except at the top, where a small aperture is left for the passage of the obturator vessels and nerve into the thigh. The chief purpose of the hole is to lighten the pelvis. The membrane serves for the origin of the obturator muscles just as well as if it had been a plate of bone: besides which, it gives a little during the passage of the head of the child. Externally, the border of the hole gives origin to the '*obturator externus*.' Between the lips of the acetabulum and the upper part of the tuberosity is a groove, in front of which the obturator externus passes to its insertion into the femur.

Behind the foramen ovale (Plate XXXVII.), the ischium presents a smooth and extensive surface which, with the corresponding part of the ilium, forms much of the lateral wall of the pelvic cavity. Observe that this surface inclines so as to form a gentle slope towards

the lower opening of the pelvis. Now it is this 'slope of the ischium' which guides the head of the child after it has entered the brim of the pelvis, and makes it turn so that the longest diameter of the head corresponds with the widest part of the outlet. The greater part of the slope gives origin to the 'obturator internus.' This muscle also arises from the margin of the obturator foramen, as well as the membrane closing it; and with this muscle we must associate the lesser ischiatic notch, because it forms the beautiful pulley (crusted in the recent state with cartilage) round which the four tendons of this muscle turn, in order to reach the thigh bone.

TUBEROSITY OF THE ISCHIUM. The tuberosity of the ischium answers a double purpose—1. It serves to support the trunk in the sitting position; 2. It forms a lever for the action of the hamstring muscles, of which one important function is to restore the body to the erect position after stooping, as seen in the annexed cut, fig. 46. Here we have a lever of the first order. The fulcrum F is at the hip-joint; the weight W is the trunk of the body; and the power P is at the tuberosity of the ischium, where the hamstring muscles arise. On the 'tuberosity' itself are the rough impressions made by the strong muscles attached to it. (Plate XXXVII.) Its well-marked outer border gives origin to the 'quadratus femoris,' behind this margin is a slightly concave surface, narrowest below, for the origin of the 'semimembranosus'; more internally, and separated by a ridge from the attachment of the last-named muscle, is an almost plane surface, from which arise, together, the 'semitendinosus' and 'biceps.' The 'gemellus inferior' arises from its upper border. At its lowest part, anteriorly, begins the origin of the 'adductor magnus,' which is continued a long way up the ramus, nearly to the body

FIG. 46.



THE TUBEROSITY OF THE ISCHIUM, A LEVER OF THE FIRST ORDER.

of the pubes. Along the inner side of the tuberosity is a rough ridge to which the greater sacro-ischiatic ligament is attached: anterior to this, but in the same line, is the origin of the 'erector penis,' and that of the 'transversalis perinei superficialis.'

The pudic vessels and nerves run along the inner side of the ischium, not quite one inch and a half from the inner margin of the tuberosity.

ACETABULUM.
ITS DIRECTION.
NOTCHES.

Lastly, we come to the 'acetabulum,' so named from its resemblance to an ancient vinegar cup. Observe its great depth and hemispherical form adapted for the secure lodgment of the head of the femur, and for more or less movement in any direction. It looks *downwards* and *outwards* (in the erect position), so as to transmit the weight of the trunk directly on to the head of the thigh bone; and the upper or iliac portion of it is by far the thickest and strongest, since it has to support the whole weight of the trunk. All these points are of interest, because they are characteristic of the human skeleton. As before stated (p. 172) it is formed partly by the ischium (more than two-fifths), partly by the ilium (less than two-fifths), and the remainder by the pubes. There are two notches in the margin or 'brim' of the acetabulum. The upper and smaller one is near the ilio-pectineal eminence, and permits the free bending of the thigh towards the abdomen. The other and larger, specially called '*the notch*,' is at the lowest part of the margin. It permits the 'adduction' of the thigh, as when we cross the legs, and also lets blood-vessels run into the acetabulum to supply the ligamentum teres, and the fat at the bottom of it. Besides which, there is no need of bone at the lowest part of the socket, which never has to support weight. Two ligaments are attached to the borders of the notch: one is the 'ligamentum teres'; the other is the 'transverse ligament' * which runs across it to complete the margin of the acetabulum. Deep as it is, even in the dry bone, the acetabulum is made still deeper in the recent state by a broad rim of fibro-cartilage, called the 'cotyloid ligament,' which, besides increasing its depth, serves as a 'sucker' to keep the head of the bone in the socket.

* The transverse ligament is sometimes ossified in extreme old age. See a preparation in the Hunterian Museum, No. 5524. Osteological Series.

EXCAVATION AT
BOTTOM OF ACETABULUM.

Looking into the socket, observe that it is smooth 'everywhere' (in the recent state crusted with cartilage), except at the bottom, where there is an irregular excavation continuous with the notch below. The use of this is to allow the free play of the ligamentum teres within the joint; it is partly occupied by fat and synovial fringes. If the socket be held to the light, the bottom of it will be found translucent. This thinness explains why, in some cases of hip-joint disease, the matter makes its way through the socket into the pelvic cavity.* It likewise explains why a fall on the trochanter major is able to fracture the bottom of the acetabulum. There is a preparation† in the Museum of St. Bartholomew's Hospital in which a fracture, caused by a fall on the trochanter a few months before death, extended in several directions from the centre of the acetabulum to its circumference.

OSSIFICATION.

Besides the three pieces of which it is originally formed, the os innominatum has four 'epiphyses,' which begin to appear about the age of puberty. One, the marginal epiphysis, skirts the crest of the ilium. There is a second for the anterior-inferior spine; a third along the tuberosity of the ischium; and a fourth, which forms a thin plate, at the symphysis pubis. The Y-shaped cartilage at the bottom of the acetabulum begins to ossify at puberty. The ilium begins to ossify first; the ischium next; the pubes last. The rami of the pubes and ischium unite about the 8th year. The acetabulum is all bony about the 17th year. All the epiphyses unite to the main bone about the 25th year.

* See Museum of St. Bartholomew's Hospital. Second Series, B. 18.

† Third Series, No. 62.

THE SACRUM.

(PLATES XXXVIII., XXXIX.)

SITUATION AND
INCLINATION.

The 'sacrum'* is situated at the back of the pelvis, and is wedged in between the two innominate bones, so as to form the 'keystone' of the arch which supports the spine, and transmits the weight of it to the lower limbs. Observe that it inclines backwards, and forms, with the last lumbar vertebra, a rounded angle, termed the 'promontory' of the sacrum. This inclination answers a double purpose: it not only makes more room in the pelvis, but breaks the force of shocks transmitted from the pelvis to the spine.

COMPOSED OF
FIVE VERTEBRÆ.

Its general shape is triangular; and a simple inspection of it proves that it consists of five vertebræ,† with their bodies and processes all consolidated into a single bone. Examine its anterior and posterior surfaces, its sides, base, and apex.

ANTERIOR
SURFACE.

Its *anterior* surface is concave from above downwards, and from side to side, in adaptation to the

* It is not easy to say why this was called the 'sacred bone' (*ιερόν ὀστέον*). The reason generally assigned is, that it was the part used in sacrifices. The following is another:—It appears the Jewish Rabbis entertained a notion that this part of the skeleton, which they call the 'luz,' would resist decay, and become the germ from which the body would be raised. Hence Butler has it—

'The learned Rabbins of the Jews
Write there's a bone, which they call "Luz,"
I' the rump of man, of such a virtue
No force in nature can do hurt to:
All th' other members shall, they say,
Spring out of this, as from a seed
All sorts of vegetals proceed;
From whence the learned sons of art
"Os sacrum" justly call the part.'

HUDIBRAS, cant. ii. part iii.

† It is not uncommon to meet with six sacral vertebræ. Sometimes there are but four. The first sacral may be detached from the lower sacral vertebræ. Again, the last lumbar may be anchylosed to the sacrum by its body, or to the ilium by one or both of its transverse processes. This last condition is frequent among the higher monkeys.

SACRUM.

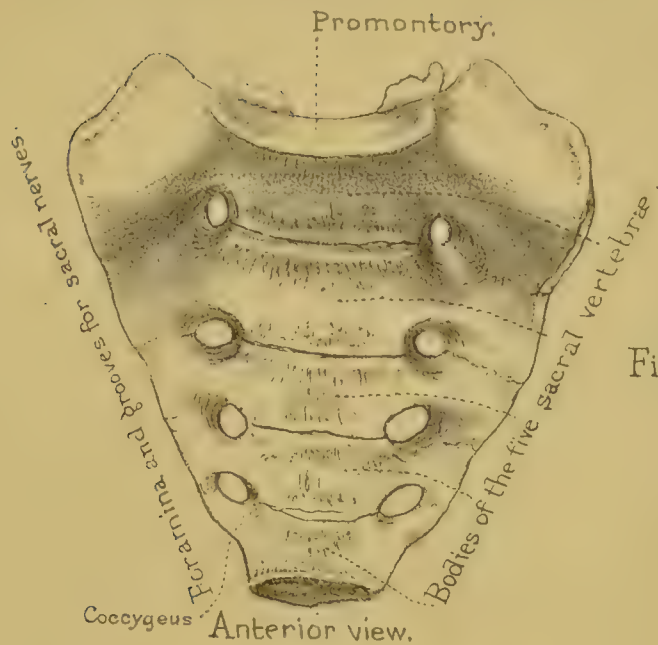


Fig. 1.

Anterior view.

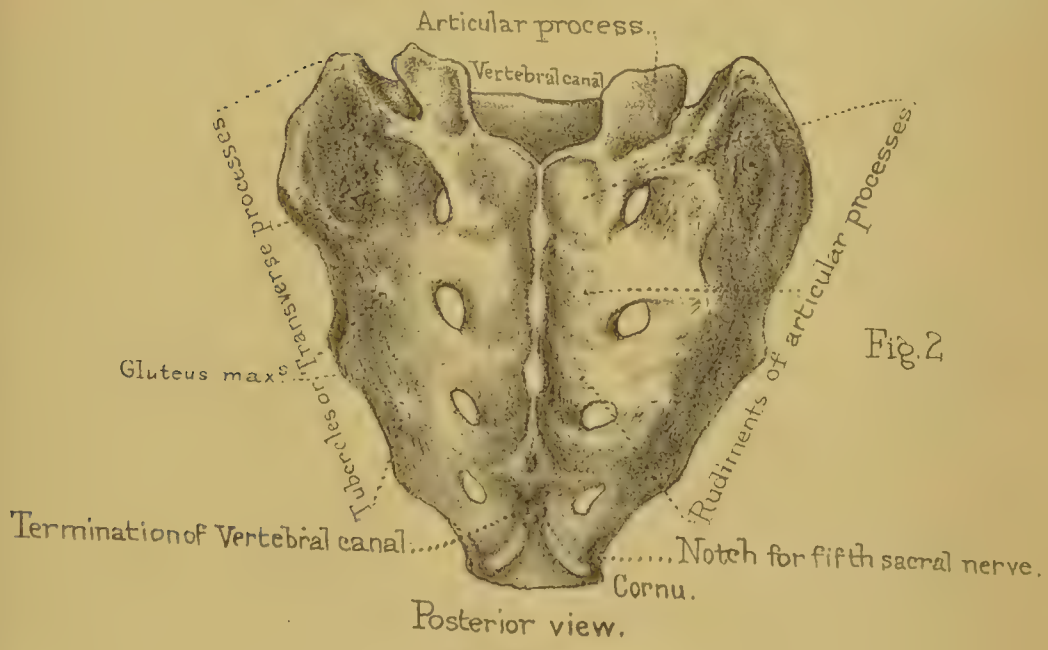


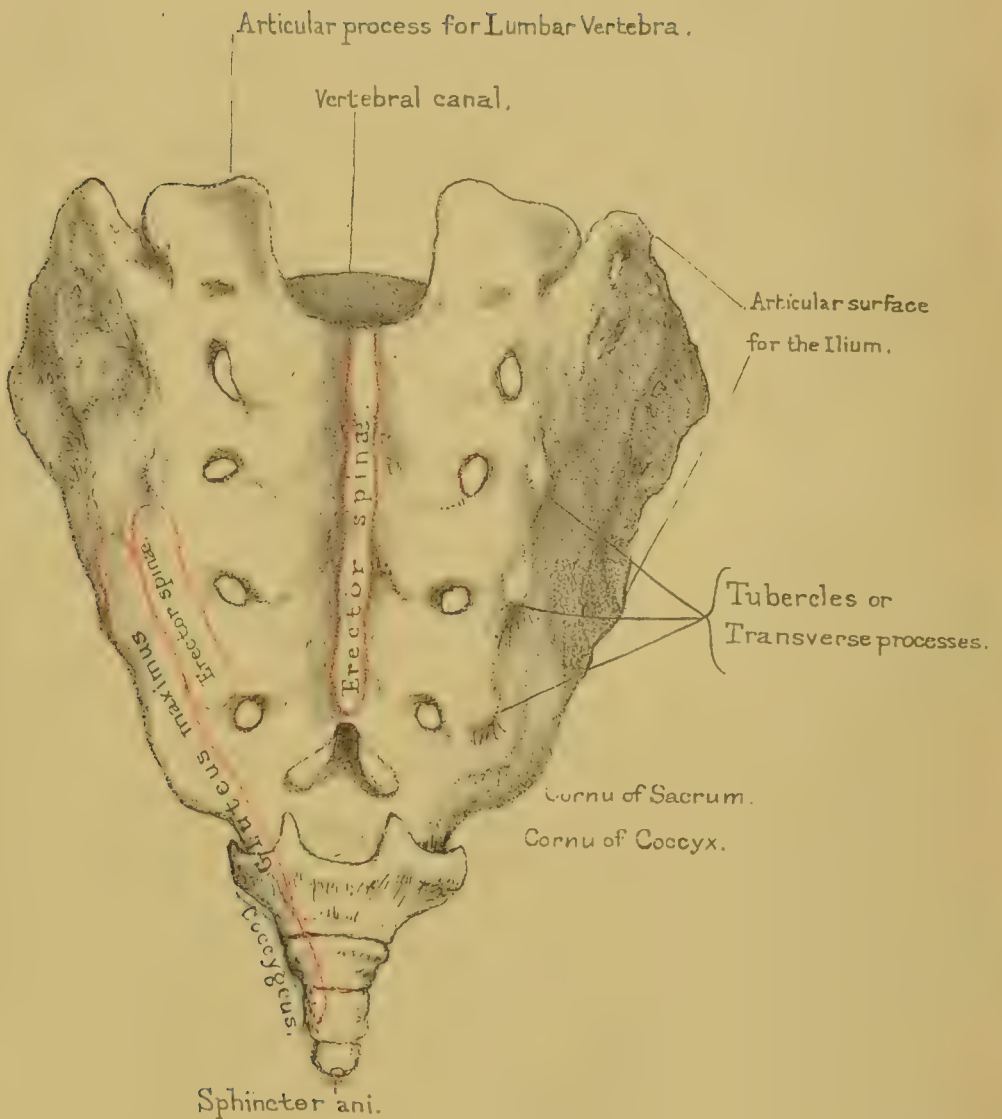
Fig. 2.

Posterior view.



Fig. 3.

COCCYX.



Posterior surface of Sacrum.
with muscles attached.

pelvic cavity. The curvature of the bone forwards, inferiorly, not only assists in supporting the pelvic viscera, but permits us to sit, which we could not have done had the bone projected like a tail. In the middle, we see the anchylosed bodies of the five sacral vertebrae decreasing in size from above downwards, and the four transverse ridges indicating their union. On each side of the ridges are the four anterior sacral foramina, with grooves leading from them for the passage of the anterior branches of the sacral nerves.

The bone exterior to the foramina, on each side, is made up of parts which in the three upper sacral vertebrae are homologous to ribs. These are united to the bodies, to each other, and also to the transverse processes behind, so as to form a solid lateral mass. Here the 'pyriformis' arises. (Plate LV.)

POSTERIOR
SURFACE.

The *posterior* surface of the sacrum is convex, and presents, in the middle line, the spines of the four upper sacral vertebrae, usually coalesced into a vertical crest for the origin of the 'erector spinæ.' Observe, however, that the last sacral vertebra, and sometimes the last two, have no spines, and that even their arches are more or less deficient, so that the termination of the vertebral canal is here left unprotected in the dry bone; and in the recent state it is covered only by a fibrous membrane. This explains the serious effects that are apt to follow an injury to this part. Sloughs from bed-sores are sometimes deep enough to expose the vertebral canal. On each side of the crest is the vertebral groove; and here are the faint traces of the anchylosed articular processes of the sacral vertebrae. The most conspicuous of these processes are those of the last vertebra: they project like two knobs of bone, and are called the 'cornua' of the sacrum: they correspond with the cornua of the coccyx, with which they are connected by ligaments.

POSTERIOR
FORAMINA AND
TUBERCLES.

Next to the articular processes are the four foramina for the transmission of the posterior sacral nerves. These posterior sacral foramina are directly opposite the anterior. Bécclard, in his lectures, relates the case of a sharp instrument running through both into the pelvic

cavity. The fifth sacral nerve emerges through the little 'notch' beneath the sacral cornu. Still more externally are the 'tubercles,' indicating the anchylosed transverse processes. These, like the crest, give origin to the tendon of the 'erector spinæ.' (Plate LI.)

BASE OF
SACRUM.

The *base* or upper end of the sacrum presents the oval surface of the body of the first sacral vertebra, which articulates with the last lumbar, a thick fibro-cartilage intervening. Holding the bone with its lower extremity properly inclined backwards, we notice that this upper surface slants downwards and forwards, forming, with the lumbar vertebra, the sacro-vertebral angle, or 'promontory,' to which allusion has been already made (page 182). On each side of the body are its thick and strong lateral masses, expanded like wings, in order to transmit the weight of the trunk to the iliac bones. Each wing has a rounded edge in front, which forms part of the brim of the true pelvis. Behind the body is the triangular opening of the vertebral canal formed by the vertebral arches. Lastly, on each side of the canal are the articular processes for the last lumbar vertebra. They are set very wide apart to give a broad base of support to the spine, look backwards and inwards, and are slightly concave from side to side, so as to permit a slight rotatory movement. In front of each articular process is the indication of the notch for the passage of the last lumbar nerve.

APEX.

The *apex* of the sacrum is formed by the diminutive body of the last sacral vertebra, and has an oval articular surface for the coccyx.

SACRO-ILIAC
SYMPHYSIS.

At the sides of the sacrum, notice the surface which is connected to the ilium, forming what is called the 'sacro-iliac' symphysis. Three sacral vertebræ concur to form it. The connection is effected, partly by cartilage, partly by ligament. The cartilaginous part is in front, and is mapped out on the dry bone in the shape of a little ear, hence called the 'auricular' surface of the sacrum. Behind this is the rough and deep excavation denoting the attachment of the strong interosseous ligament connecting the two bones. Separation of the

'sacro-iliac' symphysis does sometimes, though rarely, take place as the result of injury. It is an accident of the gravest kind, and one rarely sees recovery in such a case, since it is almost sure to be accompanied with other injury to the pelvic viscera. Lastly, the side of the sacrum below the auricular part gives origin to some of the fibres of the 'gluteus maximus.'

DEVELOPMENT
OF THE SACRAL
VERTEBRÆ.

The sacral vertebræ are developed like the others, with the addition of an independent centre on each side of the first three for the formation of the lateral mass. Now, since every vertebra has three primary centres (one for the body and two for the laminae, or arches), and two secondary centres for the body (the discs on the upper and lower surfaces), the number of centres for the five sacral vertebræ stands thus:—

$3 \times 5 = 15$ centres for the bodies.

$2 \times 5 = 10$ centres for the arches.

$2 \times 3 = 6$ additional centres for the lateral masses of the
— first three vertebræ.

$= 31$

To these we must add four epiphysial plates, two on each side, the upper for the auricular surface, the lower for the outer margin of the sacrum beneath that surface,—making in all 35 centres.

The component parts of each vertebra unite together first. Thus complete, each vertebra remains separate till about the 15th year, when they begin to unite; not all at once, but in regular succession from below upwards. The lateral masses unite before the bodies. The 'auricular' discs do not appear till about the 20th year, and the whole bone is not consolidated before the 26th year, or thereabouts. However, even in advanced age, one sometimes finds the bodies of the upper sacral vertebræ still united in the centre by cartilage only.

THE COCCYX.

(PLATES XXXVIII., XXXIX.)

CONSTITUTION
AND SHAPE.

The coccyx derives its name from a fancied resemblance to the beak of a cuckoo (κόκκυξ). It consists of four or sometimes five rudimentary vertebræ, articulated (or anchylosed) together, and successively decreasing in size, the last being a mere nodule of bone. As a whole, it is triangular. The body of the first coccygeal vertebra articulates by an oval surface with that of the last sacral: and it has two little articular processes termed 'cornua' which are connected with the 'cornua' of the sacrum, either by fibrous tissue or cartilage. The first vertebra has also two rudimentary transverse processes, and two 'notches' (one beneath each cornu), for the last sacral nerve.

The first coccygeal vertebra articulates with the lower end of the sacrum, by an intervening fibro-cartilage, and the succeeding ones are also separated by a fibro-cartilage. Thus the coccyx admits of being bent backwards and forwards, which is of great advantage in parturition, and gives as much as one inch more space in the antero-posterior diameter of the outlet of the pelvis. About the age of 45 or 50, and indeed sometimes earlier, these little bones become anchylosed to each other, and to the sacrum. This is one of the causes of difficult labour. Dr. Ramsbotham * says it is generally met with in women bearing a first child late in life, and in those who have been accustomed to sit during the greater part of the day, as in the case of milliners. Under these circumstances the bone will sometimes break in labour. It is a most distressing accident, and causes great pain when the bowels are acting.

Dr. Hunter says that anchylosis of the sacrum and coccyx is common in females who ride much on horseback, and thus explains the comparative frequency of hard labours in English ladies. Father Dobritzhofer, who lived a long time a missionary

* 'Principles and Practice of Obstetric Medicine and Surgery,' 5th edit. p. 9.

among the Abiponians, speaks of the difficult labours of the women there, who spend the greater part of their time on horseback.

OSSIFICATION. Each bone of the coccyx is ossified from a single centre. The first begins to ossify soon after birth; the second about the 5th year; the third about the 10th; and the fourth about the 15th or 20th year.

THE PELVIS IN GENERAL.

NOMENCLATURE. The pelvis is named from its resemblance to a basin ($\pi\acute{\epsilon}\lambda\upsilon\varsigma$). The French call it 'le bassin'; and in old English works it is often spoken of as 'the basin.' When accoucheurs speak of the *true* pelvis, they mean all below the brim. All above the brim they call the *false* pelvis. By the brim is understood the 'linea ilio-pectinea.' Again, they speak of the upper opening or 'inlet,' and the lower opening or 'outlet' of the pelvis.

PELVIS A LEVER OF THE FIRST ORDER.

The pelvis forms a great arch of bone which supports the trunk, and transmits the weight of it to the lower limbs. It contains and protects the pelvic viscera, and some of the abdominal. It acts as a lever of the first order in balancing the trunk on the head of the thigh-bone, as when we stand upon one leg. But the most obvious action of the pelvis as a lever of the first order, is when we raise the body from the stooping to the erect attitude. In this action the fulcrum F, as seen in fig. 47, is at the hip-joint; the weight W is the trunk of the body; and the power is fixed to the tuberosity of the ischium, P. The power in this case is the contraction of the hamstring muscles. This, by the way, is a very good example of a muscle answering a double purpose. The hamstring



THE PELVIS A LEVER OF THE
FIRST ORDER.

muscle, represented in the cut, is the biceps. When its fixed point is below, i.e. at the fibula, the muscle can raise the body from the stooping position. When its fixed point is at the pelvis, it serves to bend the knee. In the latter case, however, the muscle acts upon a lever of the third order.

Under the head of pelvis in general comes—1. Its mechanism as an arch; 2. Its obliquity with regard to the spine; 3. Its axis; 4. The diameters of the inlet and outlet; 5. The difference between the male and the female pelvis.

PELVIC ARCH:
ITS STRENGTH.

Its mechanism as an arch is best shown by sawing off the wings of the ilia, as in Plate XLI. Such a section shows the following points:—The sacrum forms the broad keystone of the arch, and supports the weight of the spine. Now the sacrum being set very oblique, the weight tends to thrust it downwards and backwards. To resist this tendency, the sacrum is doubly wedged, that is, wedged from above downwards, and from before backwards: thus, unless the ilia give way, which they never do, the sacrum cannot be dislocated *backwards*. But this is not all: there is a provision to prevent dislocation of the sacrum *forwards*; namely, a reciprocal irregularity, or slight ‘dovetailing,’ between the articular surfaces of the sacrum and ilium, and in all cases a ‘bite’ in front formed by the edge of the ilium. So much for the security of the crown of the arch.

Observe, in the next place, that the inclination of the arch is such that the weight is transmitted in a perpendicular plane to the heads of the thigh-bones. Again, the thickest and strongest part of the arch is precisely in the line of pressure. Lastly, there are three ‘buffers’ to break shocks; one at the pubic symphysis, the other two at the sacro-iliac symphyses.

SECONDARY
ARCHES.

From the main arch, two secondary arches proceed, one on either side: these are the ‘sitting arches,’ and the summit of each is at the tuberosity of the ischium.

The following is a good instance of the enormous weight the pelvic arch will bear without injury, provided the weight be applied *along the arch*. A waggon wheel passed over a man’s pelvis from side to side, immediately over the symphysis pubis.

Fig. 1.

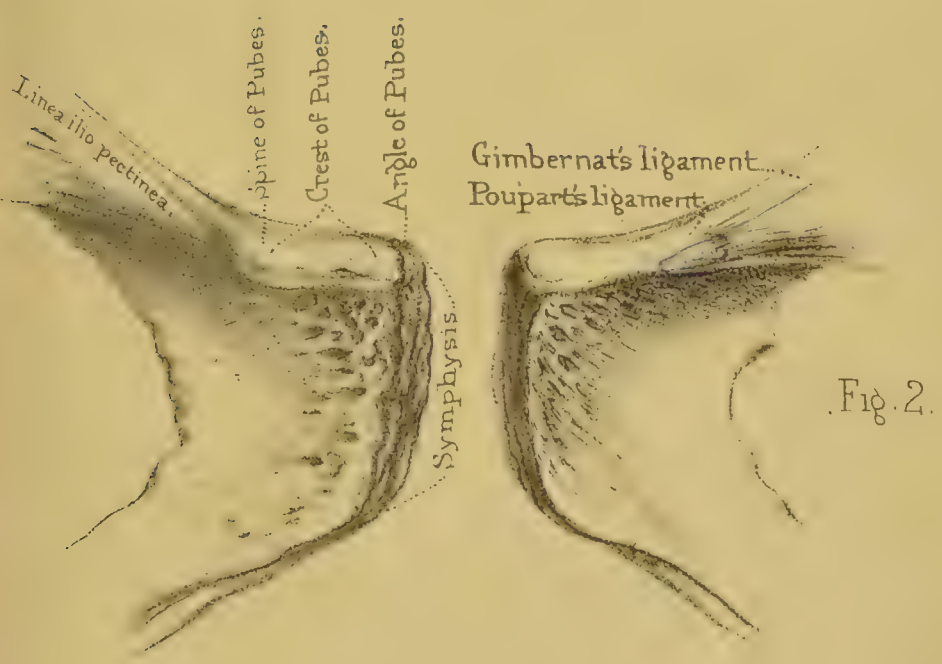
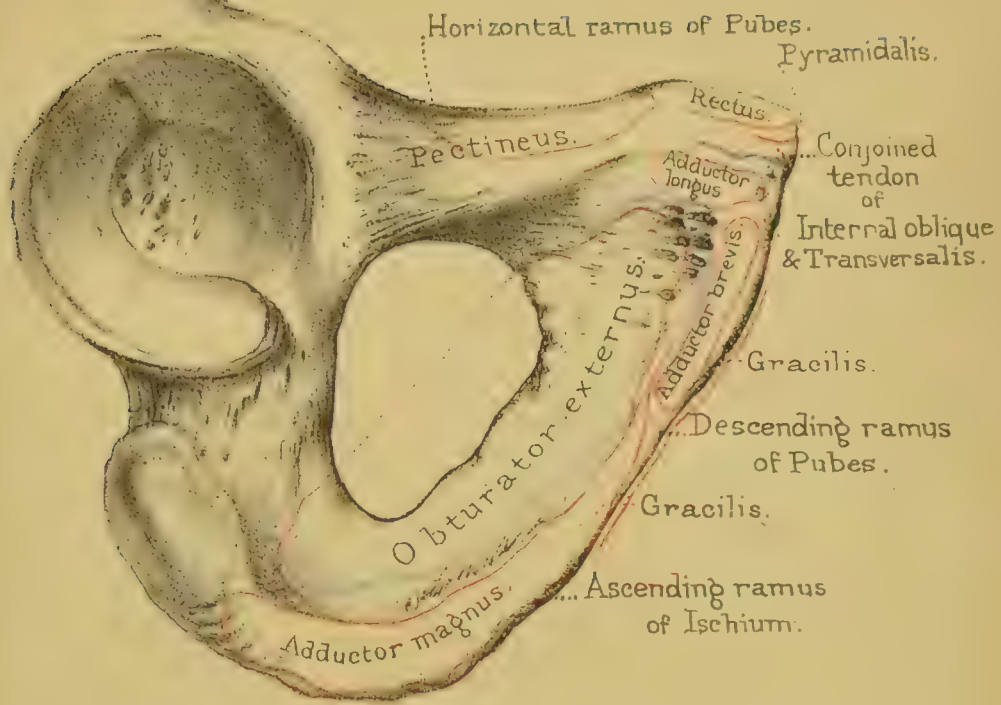


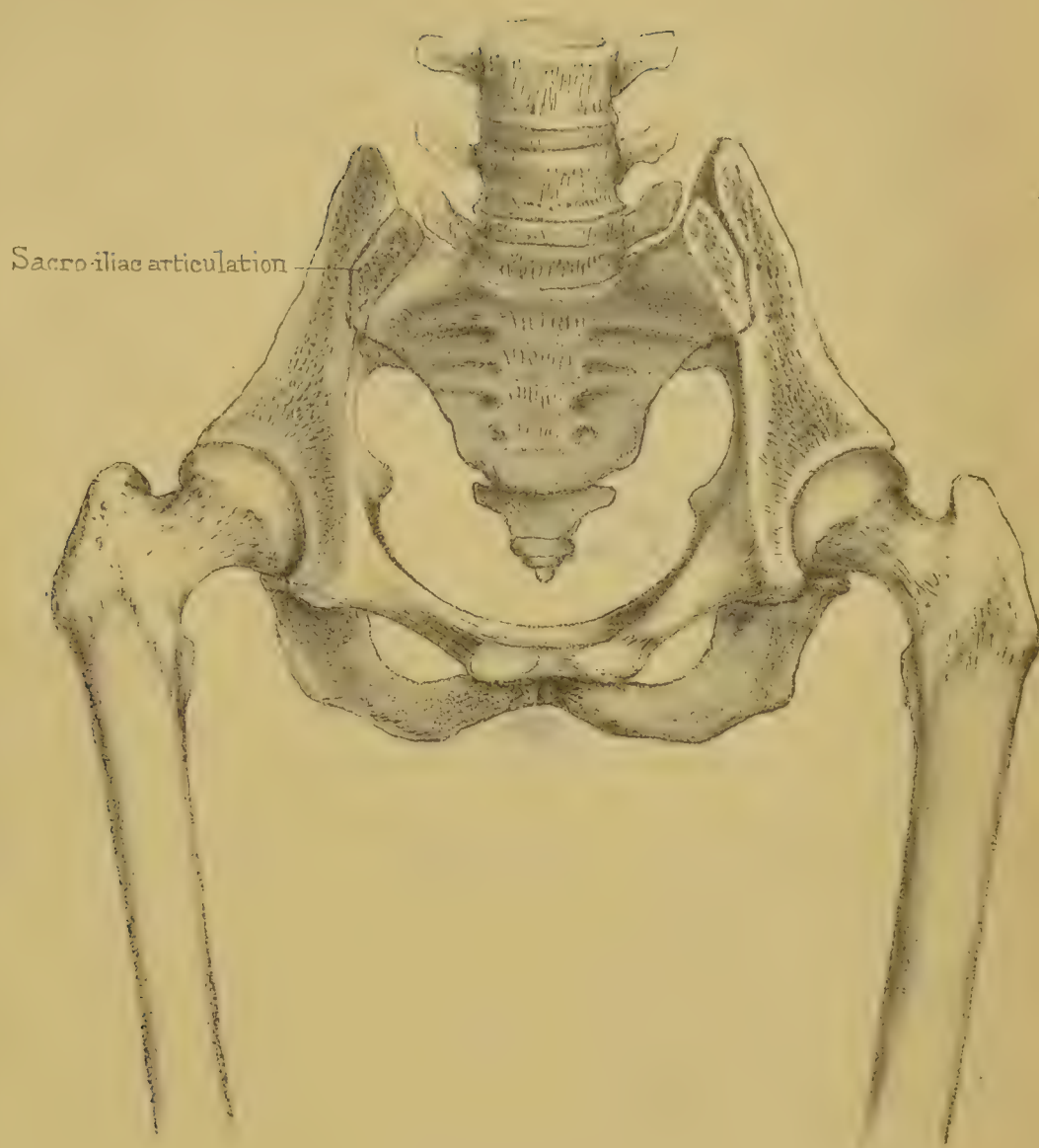
Fig. 2.

Front view of body of Pubes.

mechanism of the ear does not
 seem to me as described above. The nature
 of the sacro-cervical synchondrosis is such
 that the weight of the body transmitted
 to the vertebrae of the 5th & 6th thoracic
 & 1st & 2nd lumbar, & sacrum, & coccyx
 is not a compression of the ^{apophyses} ~~apophyses~~
 intervertebrales, as is generally supposed, but
 is, ~~rather~~ ^{rather} upward & backward, &
 is received in the sacro-cervical part of the spine.
 Besides the mechanism of the
 sacro-cervical synchondrosis, to prevent the
 rotation, the ^{thin} anterior lig. is said to
 prevent the rotating forward of the vertebrae
 for without the 5th & 6th thoracic coming
 in for it. The sacro-cervical part of
 the sacrum is not more upon a chondroid
 base in the pelvis of the pelvis, & is not so
 exactly symmetrical.



At the posterior part of the
 the posterior lig. is said to
 be a portion of the synchondrosis.
 This extends upwards, most above
 below than above. The anterior
 part of the sacrum is said to be a little
 more in the sagittal position, attached to the



Section through the upper part of the Sacrum and Iliæ,
so as to exhibit the construction of the
PELVIC ARCH.

... of the bones are just in front
of the head, and the ...
... it is ...
... a very slight rotation, ...
... that can be effected.

... the ... is ...
... to the ...
... the ...
... of the ...
... also ... that were the ...
... at all, the ... still ...
... as a ...
... to ...
... to the ...

The man stated that the waggon with the load in it weighed 5 tons 7 cwt. There was no injury beyond an ecchymosis of the scrotum and the upper part of the thighs. After three weeks, the man left the Hospital well, with the exception of a slight lameness.

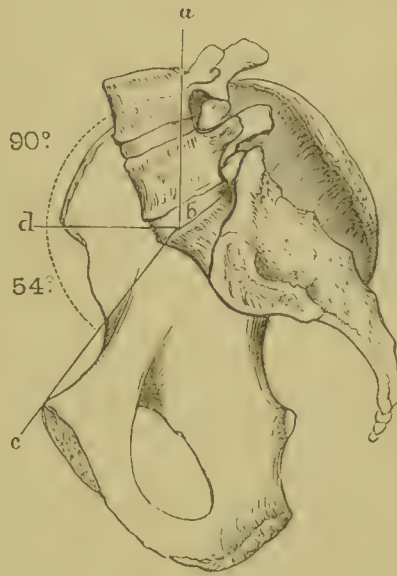
OBLIQUITY OF
THE PELVIS.

In the erect attitude the line of gravity of the spine falls perpendicularly on the sacrum, as shown in the line *a b*, fig. 48. With this perpendicular, the inclination

FIG. 48.



FIG. 49.



LINE OF GRAVITY OF THE BODY. ANGLE OF INCLINATION OF THE PELVIS, 144° .

of the pelvis forms an angle (*a b c*, fig. 49) of 140° in the female, and 144° in the male. Now this angle is such, that the line of gravity falls through the acetabulum, and consequently the weight is transmitted directly on to the heads of the thigh-bones. For all practical purposes, one may ascertain the proper obliquity of the pelvis by holding it so that the 'notch' shall be the lowest part of the acetabulum (p. 173). The end of the coccyx will then be about half an inch higher than the lower part of the symphysis pubis.

AXES OF THE
PELVIS.

The *axis of the brim* of the pelvis, that is, a line passing at right angles through the centre of its plane, if prolonged, would pass from the coccyx to the umbilicus. The *axis of the outlet* would fall on the promontory of the sacrum. The *axis of the cavity* would form a curve nearly corresponding with the curve of the sacrum. In all operations about the pelvis, it is of great importance to bear in mind its different axes. As a useful practical rule, we may say, that the axis of the pelvis corresponds with a line drawn from the anus to the umbilicus.

DIAMETERS OF
THE PELVIS.

The next point is the diameters of the pelvis; and it is interesting because it concerns parturition. The inlet or brim of the pelvis is somewhat heart-shaped. Its diameters vary more or less in different cases: in the recent state, with all the soft parts undisturbed, the following are about the average:—

	Inches
Antero-posterior or conjugate	4
Oblique (from sacro-iliac symphysis to acetabulum)	$4\frac{5}{8}$
Transverse	$4\frac{6}{8}$

Observe, then, that the longest diameter of the *brim* is the transverse. In this direction the long diameter of the head of the child enters the pelvis.

The shape of the *outlet*, in the recent state, is like a lozenge, since the two ischiatic notches are blocked up by the sacro-ischiatic ligaments. Its diameters are as follow:—

	Inches
Transverse (from one tuber ischii to the other)	4
Antero-posterior (from symphysis to coccyx)	$4\frac{1}{2}$
And, with the coccyx pushed back, the antero-posterior diameter will be	$5\frac{1}{2}$

The longest diameter of the outlet, therefore, is from before backwards.

Now the head of the child enters the pelvis in the *transverse* diameter, but descends in the *oblique*, till it presses upon the spines of the ischia. Here its further progress is arrested by the spines. As the uterus goes on contracting, the slope of the

ischium on each side compels the head to turn, so that the face comes to lie in the hollow of the sacrum. Consequently, the long axis of the head is brought into the long axis of the outlet, and is thus easily expelled.

DIFFERENCE BE-
WEEN THE MALE
AND FEMALE
PELVIS.

The female pelvis differs very little from that of the male till puberty, at which period it has a heart-shaped form in both sexes. After puberty the female pelvis begins to assume its sexual characters, which are the following:—

1. The sacrum is wider and less curved;* the promontory less projecting; and the coccyx more movable than in the male.

2. The cavity is shallower, and all its horizontal diameters broader, than in the male.

3. The spines of the ilia, the acetabula, and the tuberosities of the ischia, are wider apart than in the male.

4. The symphysis pubis is not so deep: the pubic arch has a much wider span † and its branches are more shelving than in the male, in order to facilitate parturition. To use an architectural expression, the pubic arch in the female resembles a ‘Norman’ arch; in the male, an ‘early English.’

THE FEMUR.

(PLATES XLII., XLIII.)

LENGTH AND
DIRECTION.

The thigh-bone is the longest and strongest of all the bones. Its great length, in comparison with the other bones of the leg, is characteristic of the human skeleton. In consequence of this comparative length, and of the shortness of the arms, the ends of the fingers in the white man do not reach lower than the middle of the thigh-bone. In the chim-

* Some authors state the reverse. But Albinus ‘De Seeloto’ says truly:—‘Sacrum feminis latius, per longitudinem rectius, infra non æque incurvatum in priora.’

† In his lectures ‘On the Comparative Anatomy of Man,’ 1877, Professor Flower gives 61° as the mean subpubic angle in men, 80° in women.

panzee the fingers reach down to the knee; in the ourang, down to the ankle.

The direction of the thigh-bone is not quite perpendicular, but slants, so that the knees are nearer together than the hips; for the purpose of bringing the knee-joint nearer the line of gravity of the body. This obliquity is necessarily greater in women, on account of the greater breadth of the pelvis, and accounts for their peculiar gait.

We have to examine the head, the neck, the trochanters for the attachment of muscles, the shaft, and the condyles.

HEAD.

The head forms rather more than half a sphere, smooth and convex on every part, except at a point a little *behind and below* its centre, where there is a depression for the attachment of the 'ligamentum teres.' It forms a perfect ball-and-socket joint with the acetabulum. When crusted with cartilage the ball fits so accurately into its socket, that it is retained in it by atmospheric pressure alone. It has been ascertained by experiment that this pressure is about 26 pounds; that is, more than equal to sustain the weight of the entire limb with all its soft parts. More than this, the Brothers Weber * have shown that, in walking, the legs swing like pendulums, so that we require very little muscular force to advance one leg before the other. This is a beautiful provision. The limb hangs freely in its socket, and the muscles do not expend any of their power in keeping it there. Boerhaave might well say, 'in mirabili articulatione femoris Creatorem adoramus.'

NECK: ITS DIRECTION. ANGLE WITH THE SHAFT.

The general direction of the 'neck' is upwards, inwards, and a little forwards from the shaft. The reason why the neck of the thigh-bone is directed a trifle forwards is, that the lower extremity may naturally turn a little outwards. Everything in the bones of the lower limb and the insertion of its muscles, conforms to this object. It is this which gives elasticity, freedom, and grace to the motion of the body: we owe this to nature, and not, as some suppose, to the dancing-master.

* 'Mechanik der mensch. Gehwerk.,' Gott. 1836.

In the adult the neck is set on to the shaft at a very open angle, about 125° . But the angle varies at different ages, in harmony with the requirements of the age. In children the neck of the thigh-bone is so oblique that it forms almost a gentle curve from the axis of the shaft, as seen in the cut (fig. 50). Therefore the trochanters do not project nearly so much as in the adult (fig. 51). This is one reason why it is sometimes difficult to determine the precise nature of accidents about the hip in children. As old age advances, the neck, in some instances, drops to nearly a right angle with the shaft, as shown in fig. 52: besides which its compact walls become thinner, and its cancellous tissue becomes expanded. No wonder, then, the neck of the femur is so liable to break in old persons. Observe

FIG. 50.



FIG. 51.



FIG. 52.



how much broader the neck is in its vertical diameter, and how much thicker the lower wall is than the upper, in order to resist vertical pressure. (Plate I.) The

COMPARATIVE OBLIQUITY OF THE NECK OF THE THIGH-BONE IN THE CHILD, THE ADULT, AND THE AGED. (FROM MUSEUM OF ST. BARTHOLOMEW'S HOSPITAL.)

part where the neck springs from the shaft is called the 'base' of the neck. In falls on the trochanter the neck is sometimes broken at the base, and driven into the shaft between the trochanters, forming what is called an 'impacted' fracture of the neck. The symptoms of such a fracture are, more or less shortening of the limb, diminished projection of the trochanter major, and no crepitus.

NECK, WHY OBLIQUE? Since the great length and obliquity of the neck of the femur is peculiar to man, let us consider what advantage his skeleton gains by it.—1. It widens the base of support for the trunk; 2. It disengages the shaft from the hip-joint, and thus increases the range of motion. What animal can separate its legs so widely as man? 3. Greater space is made for the adductor muscles, which balance the pelvis on the inside of

the thigh; 4. The great trochanter being removed to a distance from the hip-joint, gives greater leverage to the powerful gluteal muscles which balance the pelvis on the outside. 5. The weight of the trunk, instead of falling vertically on the shaft of the femur, is transmitted to it by an arch.

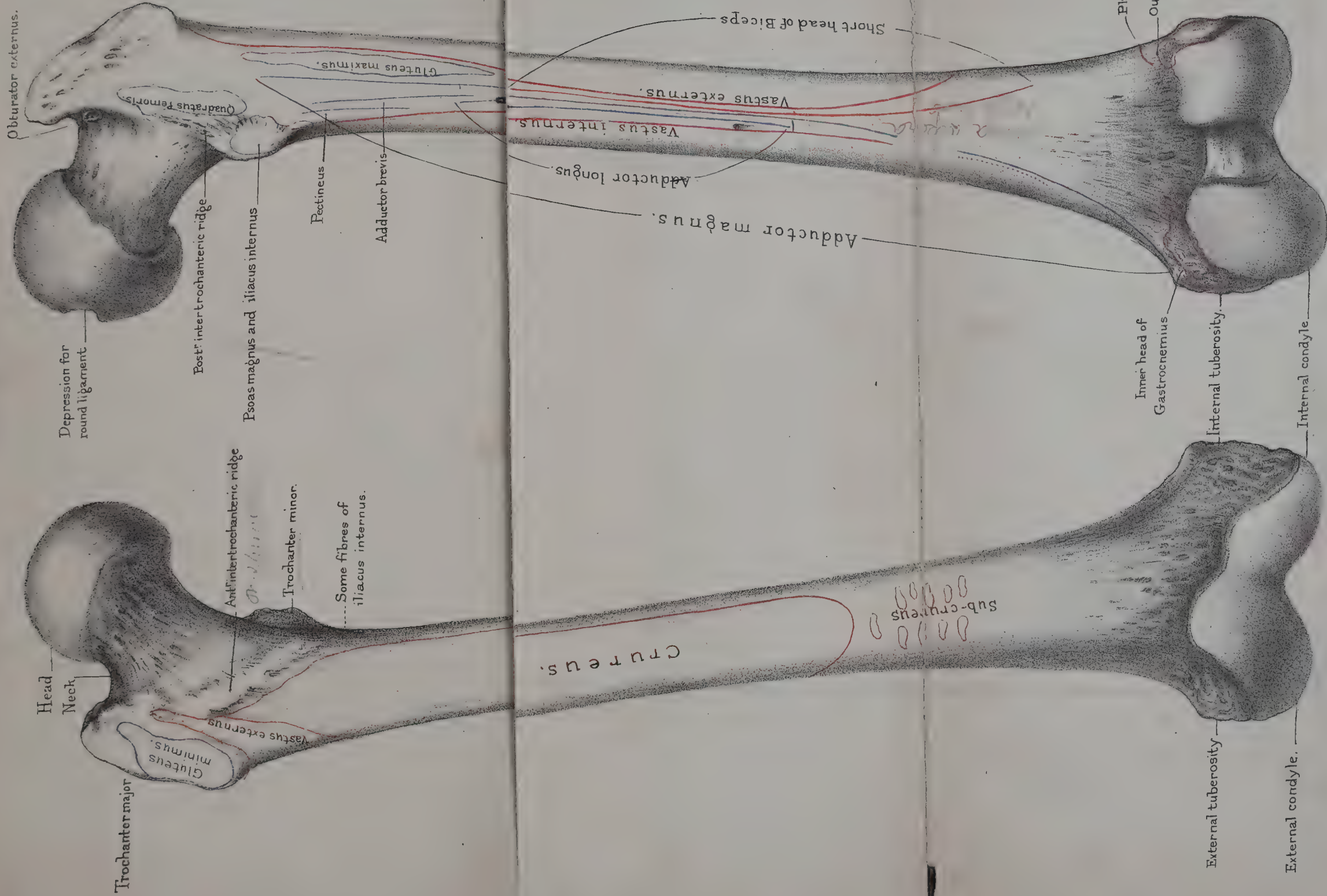
TROCHANTERS,
MAJOR AND
MINOR: THEIR USE
AND POSITION.

The trochanters 'major' and 'minor' are outstanding processes for the purpose of giving greater leverage to the muscles which rotate the thigh (*τροχάω*, *verto*). Observe, they project behind the axis of rotation (which is the centre of the head of the bone). This is another of the provisions for the outward rotation of the lower limb as the natural position. The bearings of the trochanter major to the other bony prominences of the pelvis deserve especial attention, because it is a great landmark in determining the nature of injuries about the hip. It is well then to remember that the top of the great trochanter in the adult is about three-quarters of an inch lower than the top of the head of the bone, and nearly on a level with the spine of the pubes.*

Examine first the muscles inserted into the trochanter major. Suppose the trochanter to be square, which it is nearly if seen sideways. (Plate XLIII.) Into the front part is inserted the 'gluteus minimus,' into the upper part is inserted the 'pyriformis'; also in front of the pyriformis, and extending backwards beneath it, is the insertion of the common tendon of the 'obturator internus' and 'gemelli' (just above and anterior to the digital fossa) (Plate XLIII. fig. 1); into the back part, upon an eminence on the 'posterior inter-trochanteric ridge' called the 'linea quadrati,' is inserted the 'quadratus femoris'; the lower part (base of the trochanter) gives origin to the strong tendon of the 'vastus externus.' Draw a diagonal from behind forwards across the square (there is a faint trace of it in nature), and you find that the upper triangle gives insertion to the 'gluteus medius,' while the lower triangle remains smooth for the play of the tendon of the 'gluteus maximus,' a large 'bursa' being interposed. A smaller bursa occupies the front of the upper triangle, in connection with the tendon of the 'gluteus medius.' (Plate XLIII. fig. 2.)

* See 'Medical and Surgical Landmarks,' by the Author, 2nd ed. 1877.

FEMUR.



Anterior surface.

Drawn on Stone by T. Godart.

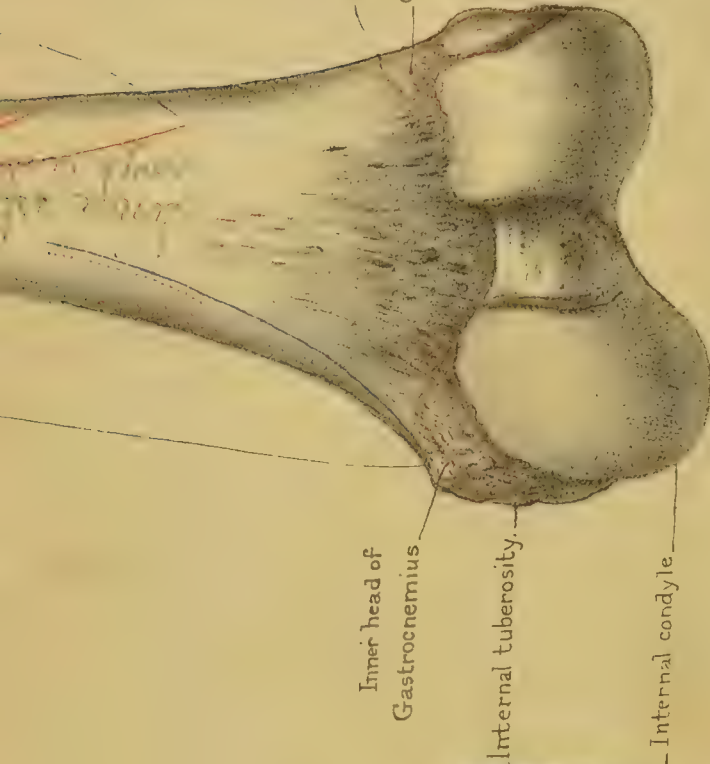
Posterior surface.



External tuberosity

External condyle

Anterior surface.



Inner head of
Gastrocnemius

Internal tuberosity

Internal condyle

Posterior surface.

Drawn on Stone by T. Godart.

Anterior view

Printed by W. West & Co.

Obturator internus & Gemelli.
Pyriformis.

Fig. 1

teus
mus

Fig. 2.

Surface over which
plays the tendon of the
Gluteus maximus.....

Gluteus medius.

Fig. 3.

Plantaris.....

.....Outer head of Gastrocnemius.

.....Attachment of external lateral ligament

.....Popliteus.

External condyle.

DIGITAL FOSSA. Behind the neck of the femur, and beneath the projecting angle of the trochanter major, is a deep excavation, called the 'digital fossa.' (Plate XLII.) The 'obturator externus' is inserted here; and this insertion is at the bottom of the fossa.

TROCHANTER MINOR. The trochanter minor projects from the inner and *back* part of the shaft, just below the base of the neck. Its posterior part gives insertion to the tendon of the 'psoas magnus,' the fibres of the 'iliacus' mostly join this tendon, but a few are inserted into the lower border of the lesser trochanter towards the linea aspera. Observe that the trochanter minor is directed backwards in order that the muscles inserted into it may turn the thigh outwards at the same time that they raise it. These are the muscles which, in fracture of the upper third of the shaft, it is often difficult to prevent from tilting up the upper fragment.

**INTER-TROCHAN-
TERIC RIDGES.** Two oblique ridges extend from one trochanter to the other, the one in front of, the other behind, the base of the neck of the femur. The use of the anterior 'inter-trochanteric ridge' is to give attachment to the powerful ligament (ilio-femoral) which covers the front of the capsule of the hip-joint, limits the extension of the thigh, and is one of the chief safeguards of the erect position, since it prevents the pelvis and trunk from falling backwards. The posterior 'inter-trochanteric ridge' is mainly for the support of the great trochanter. There is an eminence on its margin, extending downwards, behind the great trochanter called the 'linea quadrati,' for the insertion of the 'quadratus femoris' already alluded to.

**SHAFT AND
LINEA ASPERA.** Respecting the shaft of the femur, notice that it is slightly arched with the convexity forwards, by which a double advantage is gained: first, it is rendered more springy than if it were straight; secondly, more room is gained for the flexor muscles behind, and more power for the extensors in front of the shaft. The shaft is smooth and cylindrical all round, except behind, where there is a rough longitudinal ridge termed the 'linea aspera.' This ridge serves as a buttress to the shaft, but its chief purpose is for the attachment of muscles. The linea aspera is most prominent about the middle third of the shaft; here

it appears at first sight a single ridge; but look carefully and you will find traces of two borders, termed its external and internal 'lips.' About the lower third of the shaft these lips diverge from each other, and may be traced more or less distinctly to the 'tuberosities' of the condyles. The triangular interval between their bifurcation is called the popliteal surface of the femur, and upon it the popliteal artery rests in its passage through the ham. Turning to the upper end of the *linea aspera*,* notice that here also its two lips branch off: one runs to the root of the lesser trochanter, the other to the root of the greater.

So much about the *linea aspera*, and the upper and lower divergence of its two lips, will help us towards understanding the muscles attached to it. Take the *outer* lip first. The '*vastus externus*' arises from it three-quarters of the way down. Along the upper third is a very rough surface for the insertion of the *gluteus maximus*. This part may very properly be called the '*gluteal* ridge': it is sometimes so prominent as to resemble the third trochanter of animals. Lastly, there is the origin of the short head of the biceps, beginning just below the insertion of the *gluteus maximus*, and extending nearly down to the external condyle.

The *inner* lip of the *linea aspera* gives origin nearly all the way down to the '*vastus internus*.' Into its upper part is inserted the '*pectineus*,' then comes the insertion of the '*adductor longus*,' and behind both is that of the '*adductor brevis*.' Lastly, the insertion of the '*adductor magnus*' extends all along the line from the base of the trochanter major to the tuberosity of the inner condyle, where we notice a sharp projection of bone, which gives a firm hold to the tendon.†

CANALS FOR
MEDULLARY AR-
TERIES.

Along the course of the *linea aspera* are the orifices of two canals which convey nutrient blood-vessels to the marrow. Both these canals run obliquely *upwards* through the walls of the bone.

* These '*lineæ asperæ*' are nothing more than partial ossifications of the tendons inserted there. A very rough '*linea aspera*' is a character of age. It puts one in mind of the '*bone tendons*' which one sees in the regular anatomy of birds.

† The little interval purposely left in the drawing (Plate XLII.) is intended to mark where the tendon gives passage to the popliteal artery.

The front and outer surface of the shaft gives origin to the 'crureus,' and to the little muscular slips below, which constitute the 'sub-crureus.' The inner surface gives origin to part of the 'vastus internus' (the other and stronger part arising from the *linea aspera*). Observe, the origin of these muscles does not occupy the whole of the shaft. Along the lower part, but more especially on the inner side, no muscular fibres arise. Here the bone is simply covered by the fibres of the 'vasti' on each side. The point of this observation is, that it accounts for the great extent to which an inflamed knee-joint may swell beneath the vasti: there being no resistance to the distension of the synovial membrane in this direction.

CONDYLES AND
INTER-CONDYLOID
NOTCH.

The lower part of the femur gradually expands to form the condyles for the knee joint (*κόνδυλος*, a knuckle). The inner condyle projects much more, and is full half an inch lower than the outer, when the bone is perpendicular; but when the bone slants, as it naturally does, both condyles are on the same plane. This must needs be, as the plane of the knee-joint is horizontal in adaptation to the erect posture. The condyles are separated behind by a deep notch, the 'inter-condyloid,' for the lodgment of the two 'crucial' ligaments, which prevent the knee from being extended beyond the straight line: for the requirements of this joint do not admit of any bony prominence to limit extension, such as we find in the elbow. These ligaments (shown in fig. 53) are attached to the rough surfaces of the condyles facing each other; the anterior crucial to the external condyle, the posterior crucial to the internal. The marks left by these ligaments can be clearly made out on the bone. Notice especially that the mark on the external condyle is placed posteriorly, that on the internal, anteriorly.

TROCHLEA FOR
PATELLA.

The articular surfaces of the condyles unite in front to form the pulley (femoral trochlea) over which the 'patella' plays. The larger share of the pulley is formed by the external condyle, and it mounts not only higher, but projects more than the inner, to prevent the tendency of the patella

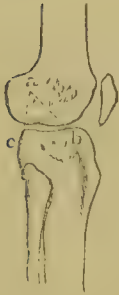
FIG. 53.



CRUCIAL LIGAMENTS
OF THE KNEE.

to be dislocated outwards. In an antero-posterior section, each articular surface would present something like the long half of an ellipse (as seen in fig. 54).*

FIG. 54.



part of the ellipse rests on the shallow excavation of the tibia, and all the ligaments are on the stretch; but when the knee is bent, the more convex part of the ellipse rests on the tibia, and admits of a certain amount of rotation, all the ligaments being loose.

TUBEROSITIES.

The 'tuberosities' (external and internal) of the condyles are for the attachment of the lateral ligaments of the joint.

Observe that these tuberosities are situated nearer to the back than to the front part of the condyle. The result of this is, that the ligaments are fixed behind the centre of motion, so that they become stretched when the joint is extended. This is another provision for the strength of the knee.

There is an impression behind the internal condyle denoting the origin of the inner head of the 'gastrocnemius'; and another, behind the external condyle, where the outer head of this muscle and the 'plantaris' arise. On the outer surface of the external condyle, immediately below the outer tuberosity, is a depression for the origin of the 'popliteus.' (Plate XLIII. fig. 3.)

OSSIFICATION OF THE FEMUR.

The femur is ossified from three primary centres (one for the shaft and neck, and one for each articular end), and two secondary centres, one for each trochanter. (See Plate IV.) The centre of the shaft appears very early (between the fortieth and sixtieth day after conception). The centre of the lower epiphysis does not appear until within the last fifteen days of the full term of gestation. Hence the existence of this centre enables us to pronounce with something like certainty as to the age of a foetus.† It is the only epiphysis in which ossification

* The two woodcuts (53 and 54) show very well the attachments and the direction of the crucial ligaments, *a b, a c*. Being attached to the condyles behind the centre, they necessarily limit extension beyond the straight line. But they do more; by crossing like braces they prevent lateral displacement of the tibia.

† Concerning the bearing of Osteogeny on forensic medicine, see 'Médecine légale,' by M. Orfila.

commences before birth. As this is the first of all the epiphyses to ossify, so it remains the longest a separate piece, in accordance with the general law that epiphyses unite with the shafts in the inverse order of their ossification (p. 25). The epiphysis at the upper end of the femur includes only the head of the bone, and begins to ossify about one year after birth. The great trochanter begins to ossify about the third or fourth year; the lesser about the fourteenth. All the pieces have united about the age of twenty-one.

THE PATELLA.

(PLATE XLIV.)

SHAPE AND USE.

The patella is the largest and best example of a 'sesamoid' bone. It is developed in the extensor tendon of the knee, to protect the knee joint, and to increase the power of the extensor muscles by making them act at a greater angle. It is a principle in mechanics that the efficiency of a force which acts upon a lever is greatest when its direction is at right angles to the lever, and that the force decreases as the obliquity of its direction is increased. In shape, the patella is triangular, with rounded angles, the apex pointing downwards.

ITS TWO SUR-
FACES.

Its anterior surface is convex, and marked by longitudinal streaks, indicative of the insertion of the fibres of the extensor tendon.

Its posterior surface is smooth, and crusted in the recent state with cartilage, in order to play upon the trochlea of the femur. It is divided by a vertical ridge adapted to the groove in the femur, and on each side of the ridge are the articular 'facets' corresponding to the condyles of the femur. The external 'facet'

RIGHT OR LEFT?

is the larger of the two in adaptation to the size and shape of the pulley on the external condyle: by this we may distinguish the right patella from the left. Besides this, the outer edge of the patella is much thinner than the inner, which is another good distinction. Below the articular surface—that is, towards the apex—there is a rough surface for the

attachment of the so-called 'ligamentum patellæ,' which is, really, the continuation of the extensor tendon. The base of the bone is thick and irregular, that the extensor tendon may have a strong insertion.

OSSIFICATION. The patella is developed from a single centre, which appears about the second year. It is not fully ossified until the age of fourteen or fifteen.

The patella, thus serving a mechanical purpose in the substance of the extensor tendon, is liable to be broken by a sudden and violent action of the extensor muscles, as in making a strong effort to preserve the balance of the body in danger of falling backwards. In this position—that is, when the knee is *half-bent*—the upper part of the patella is not supported by its trochlea: there is a hollow under it, and here the patella snaps transversely, like a stick broken across the knee. The broken ends separate widely, and therefore in these transverse fractures reunion takes place by ligamentous substance, not by bone.

But even when the knee is *extended*, violent muscular contraction is able to snap the patella. Desault speaks of both patellæ being broken by convulsions in a patient after he had been cut for the stone. Opera dancers sometimes break the patella in practising the step called the 'entrechat.'

THE TIBIA.

(PLATE XLIV.)

SITUATION AND DIRECTION. The tibia is the larger of the two bones of the leg, and is placed on the inner side. It entirely supports the condyles of the femur, and transmits the weight of the body to the foot. Its direction is not oblique like the femur, but vertical; so that in well-formed legs the two tibiæ should be parallel. Let us examine in succession the upper end, the shaft, and the lower end.

HEAD. The upper end is called the 'head' of the tibia. It is very broad in the transverse direction for the support of the condyles of the femur: and we point to this great

breadth as one of the peculiarities of the human skeleton. The two articular surfaces for the condyles are very shallow in the dry bone, but slightly deepened in the recent state by discs of fibro-cartilage (termed the 'semilunar cartilages'). These cartilages convert the shallow articular surfaces of the tibia into *variable* sockets; that is, sockets which adapt themselves to the varying forms of the condyles in flexion and extension of the knee. The outer articular surface is round; the inner is oval, with the long diameter from before backwards, in adaptation to the internal condyle. Between the articular surfaces is a projection termed the 'spine,' which is generally topped by two little 'tubercles.' In front of the spine is the depression in which the anterior crucial ligament is attached, and behind the spine is another much larger, in which the posterior crucial ligament is attached. These depressions serve also for the attachments of the semilunar cartilages.

TUBEROSITIES,
EXTERNAL AND
INTERNAL.

The lateral masses which support the articular surfaces are called the 'tuberosities' of the tibia.

The *external* tuberosity has at its back part a small articular surface for the head of the fibula: this articular surface is on a kind of bony ledge, and its direction is oblique. The *internal* tuberosity is much larger, and projects more than the external. It has a groove behind for the insertion of the 'semi-membranosus.' About one inch and a half below the head of the tibia, and in front of it, is the 'tubercle' for the insertion of the common extensor tendon of the leg (ligamentum patellæ). Observe that the insertion takes place into the lower part of the tubercle, which is rough; the upper part is smooth, to allow the easy play of the tendon (a bursa being interposed between the tendon and the bone).

SHAFT: ITS
SHAPE AND SUR-
FACES.

The shaft of the tibia is triangular. It is a little twisted outwards, to determine the obliquity of the foot; consequently the inner malleolus advances a little more than the outer. This disposition, observe, corresponds with the obliquity of the neck of the femur, the position of its trochanters, and the oblique direction of the muscles; the object of all being to give a natural inclination *outwards* to the lower extremity. The narrowest part of the

shaft is about the lower third. This is the part most frequently broken.

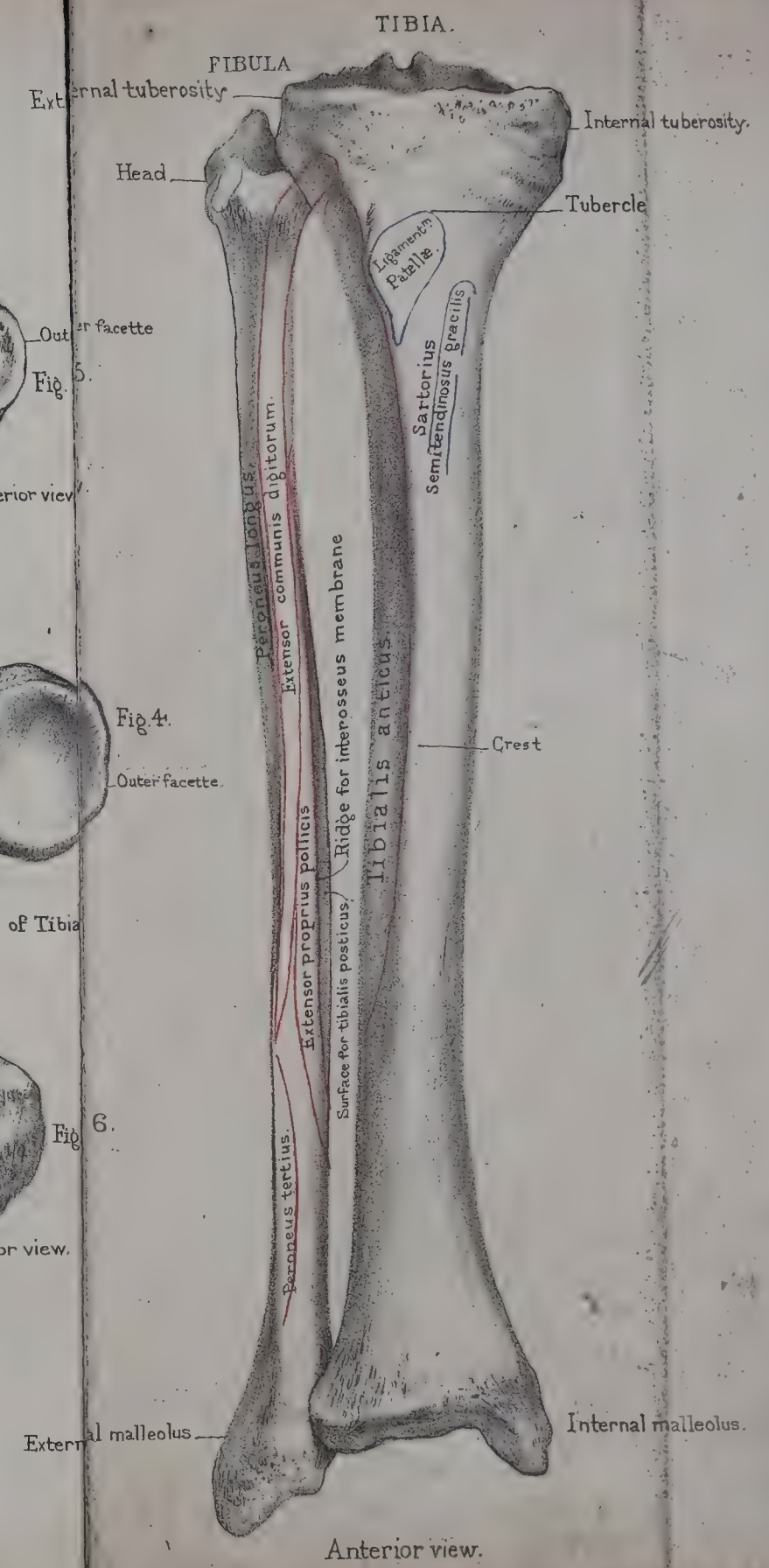
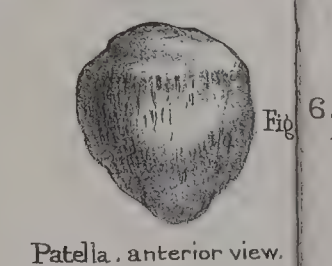
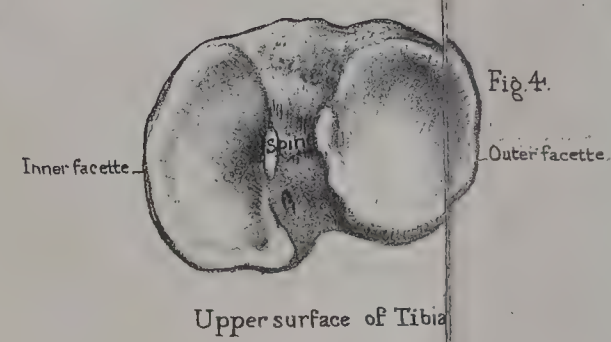
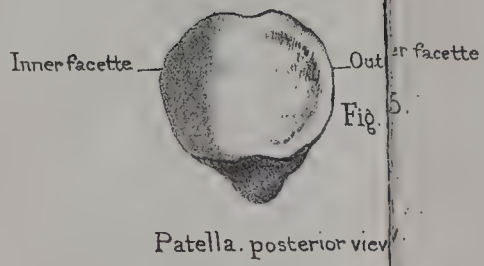
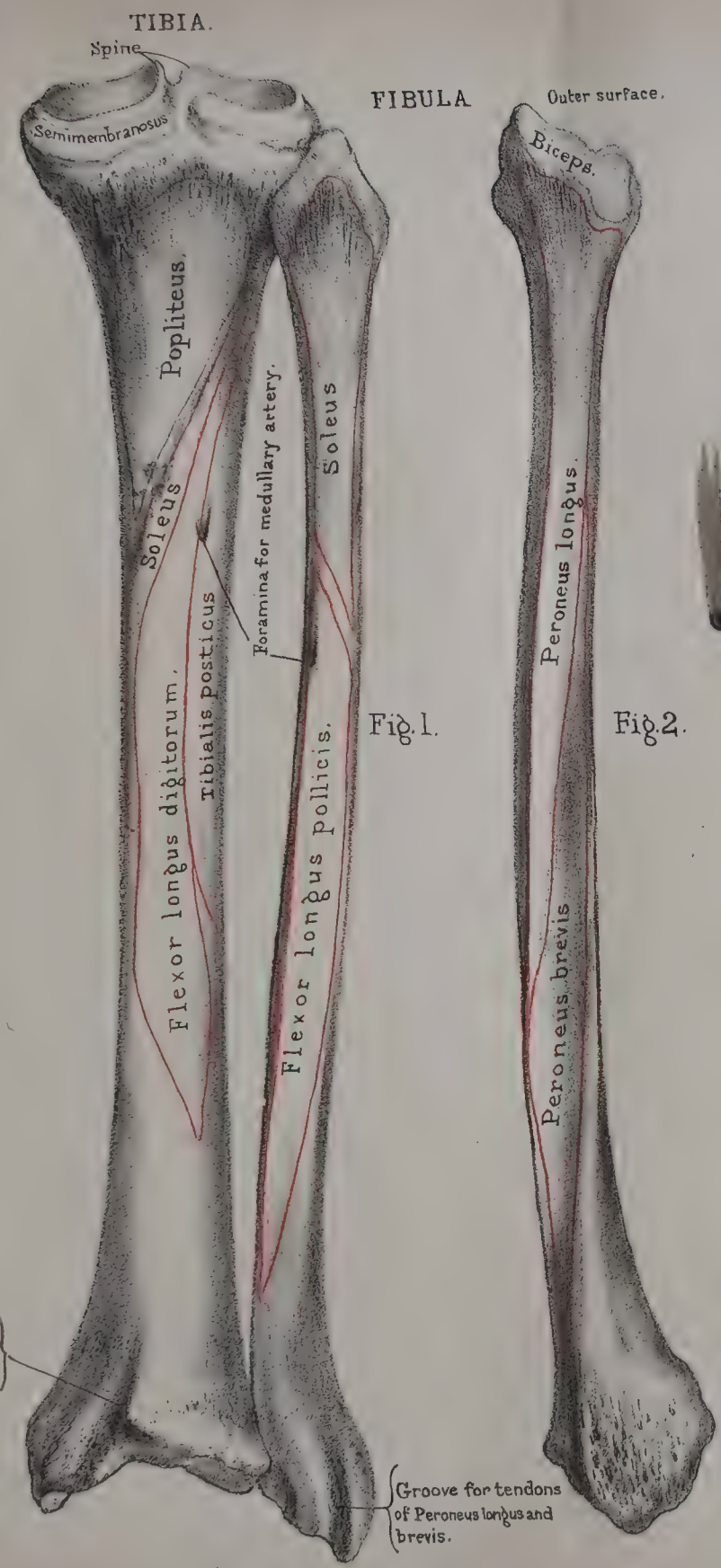
The *internal* surface is subcutaneous. Notice on it, below the internal tuberosity, the insertions of the 'sartorius,' 'gracilis,' and 'semitendinosus.' Behind these is a rough surface for the attachment of the internal lateral ligament of the knee.

The *external* surface is slightly hollowed along its upper half for the origin and lodgment of the 'tibialis anticus'; its lower part is turned forwards, so as to present a smooth surface adapted for the play of the tendons which run over the front of the ankle-joint.

The *posterior* surface presents along its upper third a rough line ('soleal ridge') slanting from the outer towards the inner side. It marks part of the tibial origin of the 'soleus'; the remainder of this origin runs down the inner edge of the shaft to the extent of about three inches. This origin is important, since it concerns the operation of tying the posterior tibial artery. Above the 'oblique line' is a triangular surface, indicating the insertion of the 'popliteus.' The surface of the bone below the ridge is occupied, internally, by the origin of the 'flexor longus digitorum,' externally, by part of the origin of the 'tibialis posticus.' Just below the line is the canal for the medullary artery. It is the largest of all the like canals in the long bones, runs very obliquely from above downwards, and when divided in amputations sometimes occasions troublesome hæmorrhage. I have many times traced a nerve through this canal with the artery into the medullary cavity.

EDGES.

With regard to the edges of the tibia, the *anterior*, called the 'crest,' or 'shin,' is very sharp, and readily felt beneath the skin, but only along the upper two-thirds of the shaft: along the lower third the front of the bone is flattened, for the passage of the extensor tendons and the anterior tibial vessels and nerve. The *external* edge looks towards the fibula, and gives attachment to the interosseous membrane (represented by the dotted line in fig. 55) which connects the two bones. The *internal* edge runs from the hinder part of the head of the tibia down to the inner malleolus. It gives



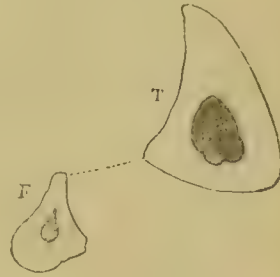
Groove for tendons of Tibialis posticus and Flexor longus digitorum

Groove for tendons of Peroneus longus and brevis.

attachment to the deep fascia covering the muscles of the back of the leg, beneath those of the calf.

The *crest* or 'shin' of the tibia is the densest and strongest part of the bone (see fig. 55), for this reason, that the chief strain on the tibia is at the anterior part; which is at once obvious if we consider the direction of the force in walking, running, or leaping. This form of the tibia is not a mere matter of accident, or the result of the action of the muscles which surround it.

FIG. 55.



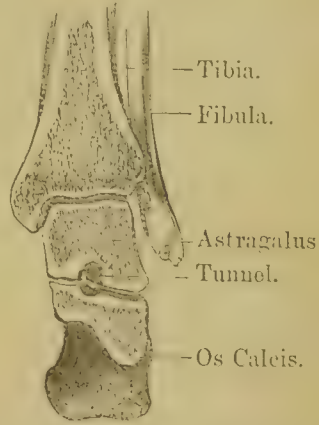
SECTION THROUGH THE TIBIA T, AND FIBULA F, TO SHOW THE THICKNESS OF THEIR WALLS.

LOWER END.

The lower end of the tibia is expanded transversely to form a hinge-joint with the astragalus.

Its articular surface is concave from before backwards; but the transverse plane of the joint is horizontal (as seen in fig. 56), like that of the knee, for the advantageous support of the weight of the body. The joint is secured on the inner side by the projection termed the 'malleolus internus.' The outer side of this projection is smooth and crusted with cartilage, to articulate with the lateral surface of the astragalus; the inner is subcutaneous. At its apex there is a deep notch for the attachment of the internal lateral ligament of the ankle; and behind it is a longitudinal groove, which transmits the tendons of the 'tibialis posticus' and the 'flexor longus digitorum.'*

FIG. 56.



SECTION TO SHOW THAT THE PLANE OF THE ANKLE-JOINT IS HORIZONTAL.

Lastly, on the outer surface of the lower end is the rough excavation for the reception of the fibula. There is no sensible movement between the bones, but just enough to give a slight amount of elasticity. The security of the ankle requires that they be

* External to this groove, there is, in some bones, a slight depression for the tendon of the flexor longus pollicis.

firmly riveted together by a strong interosseous ligament; and their contiguous surfaces are rough for this purpose.

FIG. 57.

EPIPHYSIS OF THE
TIBIA.

The ankle joint is such a perfect hinge that when the foot is at right angles to the tibia, as in standing, no *lateral* movement whatever is permitted; but when the foot is extended, then a very slight lateral movement can take place between the tibia and the astragalus, owing to the astragalus being narrower behind than in front.

OSSIFICATION.

The tibia is ossified from three centres: one for the shaft, and one for each end. The centre of the upper end, which, observe, includes the tubercle (see fig. 57), appears just before or just after birth, nearly as early as the lower epiphysis of the femur. The centre of the lower end appears about the second year. The epiphyses do not unite with the shaft till the age of twenty or upwards.

THE FIBULA.

(PLATE XLIV.)

RELATIVE BEARING OF THE TIBIA AND FIBULA.

The 'fibula' (a clasp) is the outer of the two bones of the leg. Though quite as long as the tibia, it is a slender bone, and does not sustain any of the weight of the body. The upper end is placed on a lower level than the knee joint, and forms no part of it; but the lower end projects considerably below the tibia, and constitutes the outer ankle. The use of the bone is, not only to secure the ankle externally, but to give additional extent of origin to the powerful muscles of progression. Look well at the relative position of the two bones of the leg in an articulated skeleton. Observe that the fibula articulates with the outer and back part of the head of the tibia, and that the shaft of the fibula arches

backwards, while that of the tibia arches *forwards*: the result of this is, that the fibula lies very much in the background, except at its lower part, where it advances to form the malleolus externus. A knowledge of this relative bearing of the two bones is important in the adjustment of fractures, but more especially in the performance of flap-amputations; and for this reason: that the knife, introduced from the tibial side, is apt, unless properly directed, to pass *between* the two bones, instead of behind them: and this is the more likely, since the plane of the posterior surface of the tibia slants considerably in front of the fibula. The relative position of the two bones, as well as their relative thickness, is shown by a transverse section (fig. 58). The dotted line represents the interosseous membrane.

FIG. 58.



HEAD.

The upper end of the fibula is called its 'head,' and can be felt plainly beneath the skin. On its inner side is the small oval surface which articulates with the tibia. Its outer side is very prominent, and rises behind into a short projection termed the 'styloid process.' This little process, apparently *insignificant*, is really significant, because it in all probability tallies with the olecranon. It forms a little lever * for the insertion of the biceps (one of the hamstring muscles). Besides this, the outer part of the 'head' gives attachment to the external lateral ligament of the knee joint.

SHAFT, SUR-
FACES, AND RIDGES.

The shaft of the fibula is not easy to understand unless connected with the tibia. Immediately below the head, the shaft is rounder and thinner than elsewhere. The lower three-fourths of the shaft is triangular, for the more convenient origin and course of the muscles. Its three surfaces are placed so that one (internal) looks towards the tibia; another looks outwards; the third looks backwards.

RIDGE FOR
INTEROSSEOUS
MEMBRANE.

The inner or tibial surface is divided into two unequal parts by a longitudinal ridge. Observe this ridge carefully, because it gives attachment

* To see this process developed into a lever of great power, look at the skeleton of the Echidna, or *Ornithorhynchus*.

to the interosseous membrane which separates the muscles on the front from those on the back of the leg. Now the grooved surface behind the ridge in question gives origin to part of the ‘tibialis posticus’; that in front of it gives origin to the ‘extensor communis digitorum,’ (which arises also from the head of the fibula and the tibia,) to the ‘extensor proprius pollicis,’ and to the ‘peroneus tertius.’ Thus, four muscles arise from the *inner* side of the shaft; of these, three are situated in front of the interosseous membrane, and one behind it.

The *outer* surface of the shaft gives origin to the ‘peroneus longus’ above and ‘brevis’ below. Towards the lower end of the bone this surface inclines backwards, because the tendons of these two muscles play along the groove behind the external malleolus.

The *posterior* surface gives origin to two muscles only; namely, along its upper third to the ‘soleus,’ and its lower two-thirds to the ‘flexor longus pollicis.’ Here we observe the canal for the medullary vessels: like that in the tibia, it runs downwards.

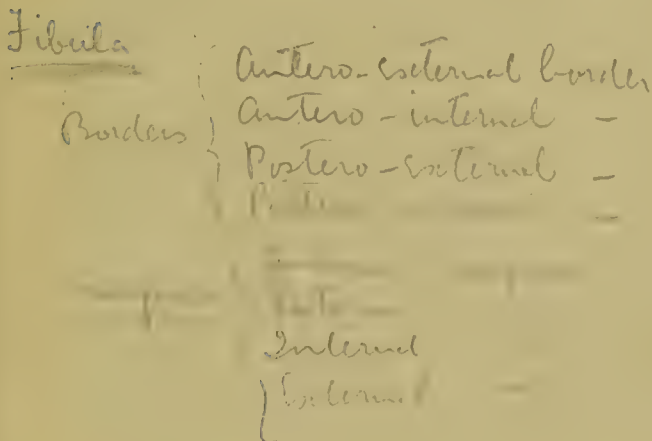
The anterior border of the shaft is the sharpest, like that of the tibia. Trace it down the bone, and you find that it bifurcates about three inches from the lower end, and encloses a triangular surface, which is subcutaneous. Here we feel for fractures of the lower part of the fibula.

LOWER END. The lower end of the fibula descends below the
MALLEOLUS EX- tibia in order to form the ‘malleolus externus’
TERNUS. for the security of the ankle joint on the outer side. It is not only longer than the inner ‘malleolus,’ but projects more, so as to give more power to the tendons of the ‘peronei,’ which play in a groove behind it. On its inner side is the smooth, slightly convex, triangular surface which articulates with the side of the astragalus; and just above this is the rough surface which fits into the groove of the tibia, and gives attachment to the interosseous membrane which rivets the two bones together. The apex gives attachment to the external lateral ligament of the ankle. On the inner side of the apex is a hollow for the attachment of the transverse ligament of the ankle, which in the recent state helps

to deepen the articular surface of the tibia behind, and adapts it better to the astragalus.

The tibia and fibula are so fixed together at the ankle, that there is no sensible motion between them; only just enough to give a little elasticity. The office of guarding the ankle is performed so well by the fibula, that lateral dislocation cannot take place unless the fibula be broken. Fractures of the fibula generally occur about $2\frac{1}{2}$ inches from the lower end, and most frequently happen in consequence of a violent outward twist of the foot, as in slipping off the curb-stone. The outer surface of the os calcis comes to press against the end of the fibula; the result of which is, that the shaft of the bone gives way at the weakest part—that is, just above the ankle. The same accident may happen from a violent twist of the foot *inwards*: but in this case it is the astragalus which, by its pressure outwards, causes the fibula to break. This kind of fracture, accompanied, as it usually is, with fracture of the tip of the internal malleolus, is one of the most frequent injuries about the ankle received into a London hospital. Such an accident is commonly called ‘Pott’s fracture,’ after the celebrated surgeon who first described it.

OSSIFICATION. The fibula has three centres of ossification; one for the shaft, and one for each end. The lower end begins to ossify about the second year; the upper about the third or fourth. Contrary to the rule (p. 25), the lower end unites the first to the shaft; the reason of this exception would appear to be the necessity of the early solidity of the ankle joint.



THE BONES OF THE FOOT.

(PLATES XLV., XLVI.)

NUMBER OF
BONES.

THERE are twenty-six bones in the foot (excluding the two sesamoid bones of the great toe, and two others in connection with tendons):—In the tarsus, seven—namely, the ‘astragalus,’ ‘os calcis,’ ‘os scaphoides,’ three ‘cuneiform bones,’ and the ‘os cuboides’; in the metatarsus, five: the remaining fourteen belong to the toes.

REASON OF THE
MANY BONES.

Why should there be so many bones in the foot? The answer is the same for the foot as for the hand—in order that there may be so many joints. The structure of a joint not only permits motion, but confers elasticity. Suppose that, instead of seven bones in the tarsus, there had been only one bone, like a shoemaker’s last, how much more liable it would have been to fracture and dislocation!

ARCHES OF THE
FOOT, LONGITUDI-
NAL AND TRANS-
VERSE.

Concerning the mechanism of the foot, which will be more fully described hereafter (p. 225), we need now only say that the bones of the foot form two arches: one, ‘longitudinal,’ extends in the long axis of the foot; the other, transverse, is most marked at the instep. The longitudinal arch is supported, behind, by the os calcis, and in front by the heads of the metatarsal bones. Its height and span are greatest on the inner side of the foot; and gradually decrease towards the outer side. The marks made by wet feet show how much more the outer border of the foot comes in contact with the ground than the inner. The weight of the body falls perpendicularly on the astragalus, which is the key-stone or crown of the arch. Concerning the astragalus, two points must be borne in mind:—1. A part (the head) of it is supported below by a remarkably strong and slightly elastic ligament (calcaneo-scaphoid), which admits of its rising and falling like a spring:

2. It is articulated with the os calcis and the scaphoid in such a way as to allow the lateral motions of the foot (adduction and abduction). Flexion and extension of the foot, observe, are performed at the *ankle joint*. But, besides these beautiful provisions, all the bones of the foot are more or less movable on each other, so as to break shocks and increase elasticity; and yet their mutual connection is so well secured, that dislocation of any one bone is extremely rare.

It is wonderful what habit and necessity will make the foot accomplish. We, who coop it in tight boots, can hardly believe it when we hear of persons carving, writing, and even painting with the toes. 'Pes altera manus' is not so far off the mark. Not long ago, a French artist, Ducornet, born without arms, used to paint with his toes pictures worthy of a place in the French Exhibition.

FIG. 59.



THE FOOT A
LEVER OF THE
FIRST ORDER.

The foot is a lever of the first order for raising the body. The fulcrum (which is a movable one) is at the ankle joint F (fig. 59); the weight W is at the toes; and the power (which is the contraction of the muscles of the calf) is at the heel P. All the conditions are those of a lever of the first order. The power and the weight act in the *same* direction on *opposite* sides of the fulcrum. The pressure upon the fulcrum is equal to the *sum* of the pressures applied, i.e. $P \times F + W \times F$.*

* It is fair to state that some regard the foot as a lever of the second order, making the toes the fulcrum. There is room, then, for two opinions on the question.

THE ASTRAGALUS.

(PLATE XLV.)

THE KEY-
STONE: ITS SIX
ASPECTS.

The astragalus (*ἀστράγαλος*, talus, the huckle-bone, with which the ancients used to play at dice), is the key-stone of the arch of the foot, and supports the whole weight of the body, which, in the erect position, falls perpendicularly upon it from the tibia. It is so much concerned in the mechanism of the spring of the foot, that the Germans call it the 'spring bone.' To examine it thoroughly we must study its six aspects.

SUPERIOR
ASPECT.

Its superior aspect, broad and *horizontal* in the transverse direction, the best adapted for the erect posture, presents a pulley-like convexity in the antero-posterior direction, to articulate with the tibia, and admit of the flexion and extension of the ankle. In front of this is the rough surface or 'neck,' for the attachment of ligaments. Observe that the pulley-like surface is at least one-fifth of an inch broader in front than behind. The object of this is to prevent dislocation of the astragalus backwards, which would otherwise be a more frequent occurrence, considering the direction of the force in walking, running, or leaping. In consequence of this greater narrowness of the astragalus behind, the ankle joint admits of a very slight lateral movement, when the foot is extended. But there can be no lateral movement at the ankle when the foot is at right angles to the tibia, i.e. when we stand upon it.

LATERAL
ASPECTS.

Each lateral aspect presents an articular surface adapted to the corresponding malleolus. The outer is much the larger, slightly concave from above downwards and triangular with the apex below. The inner is comparatively small, rounded in front and pointed behind; it occupies very little of the bone, so that a large rough excavation is left below, for the attachment of the enormously strong internal lateral ligament upon which the security of the ankle so much depends.

POSTERIOR ASPECT. Its posterior aspect is narrow and presents nothing remarkable, except a groove running obliquely downwards and inwards for the tendon of the flexor longus pollicis, and a projection on the outer side of it for the attachment of the posterior division of the external lateral ligament of the ankle.

ANTERIOR ASPECT. The anterior aspect presents a large convex 'head,' which is received into a socket, formed, in front, by the scaphoid; below, by the 'sustentaculum tali' (part of the os calcis); also by a strong and slightly elastic ligament which fills up the gap left, on the inner side and below, between these bones in the skeleton. (Plate LVI.)* It is this ligament (calcaneo-scaphoid) which mainly supports the arch of the foot, and gives it its beautiful spring. If this ligament yield more than it should do, as is sometimes the case in weakly persons, or in opera-dancers, from excessive straining, or in bakers, from carrying heavy weights, down goes the arch—the foot becomes flat, and the astragalus may sink low enough to touch the ground.

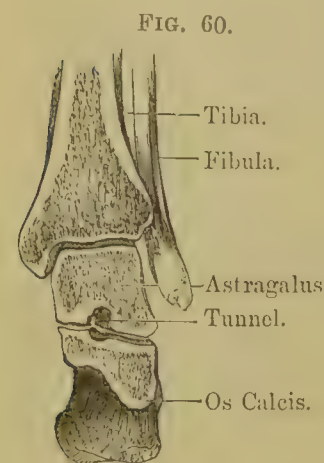
INFERIOR ASPECT. SURFACES AND GROOVE. The inferior aspect rests on the os calcis by two articular surfaces, one behind the other, and separated by a deep groove directed from the inner side obliquely outwards and forwards. Of these surfaces, the posterior is by far the larger, and placed a little more external than the anterior. Observe, also, that the posterior is concave, the anterior flat, and that both of them slant a little downwards and forwards. The consequence of this is, that when the foot sustains the weight of the body, the astragalus slides a little forwards on the os calcis, and presses with its head firmly against the scaphoid bone and the calcaneo-scaphoid ligament underneath, which, being somewhat elastic, yields a little, so that the foot becomes longer. But this is not all. When we step forward, while the foot is raised, the bones (os calcis and scaphoid) roll easily below the astragalus, so that the toes may be directed to suit the inequalities of the ground: but, the foot once planted, the body rests perpendicularly

* Sometimes the under surface of the 'head' has two separate 'facets' to articulate with the os calcis. These, according to Camper, are distinctly marked in children; and he believes that they become united in adults, owing to the pressure to which they are subjected by the practice of wearing high heels.

on it, the astragalus sinks into its socket, presses the os calcis backwards and the metatarsal bones forwards, and thus we have a steady base of support.

TUNNEL OF THE
TARSUS.

The groove just alluded to, between the articular surfaces of the astragalus, corresponds with another between those of the os calcis. When the bones are together, the grooves form a complete tunnel (*canalis tarsi*) beneath the astragalus, wide on the outside, but narrow on the inside of the foot (fig. 60). This tunnel is occupied in the recent state by fat and by the strong interosseous ligament which connects the two bones: and its direction is obliquely from before backwards, to permit the free *lateral* movements of the foot, which take place, not at the ankle joint proper (which is a simple hinge), but between the astragalus and the bones with which it articulates *below*. The astragalus cannot



SECTION TO SHOW THE TUNNEL
OF THE TARSUS.

be displaced from the os calcis without rupture of the interosseous ligament.

OSSIFICATION.

It is ossified from a single centre, which appears about the seventh month.

CONNECTIONS.

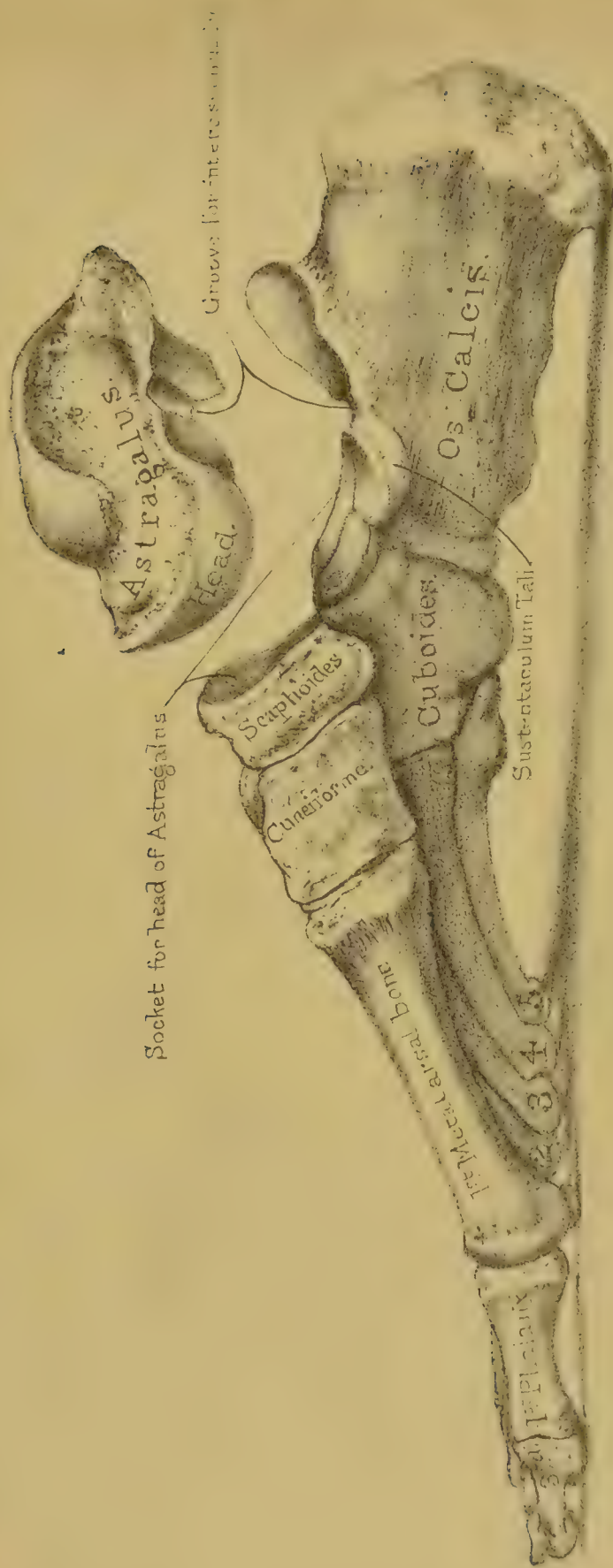
The astragalus articulates with four bones—namely, the tibia, the fibula, the os calcis, and the scaphoid.

OS CALCIS, OR CALCANEUM.

(PLATES XLV., XLVI.)

USE.

The os calcis, or 'calcaneum,' is the longest and strongest of the tarsal bones. Its office is to transmit the weight of the body to the ground, and form a powerful lever for the muscles of the calf. The great projection



Drawn on Stone by T. Godart.



and nearly horizontal direction of the heel are peculiar to the skeleton of man, in adaptation to his erect position. There is a certain relation in the human subject between the projection of the os calcis and the size of the muscles of the calf: namely, if the heel be short, the calf will be large; and *vice versâ*, if the heel be long, the calf will be small. The reason is obvious: a short heel or lever requires the stronger muscle, and the reverse.

There is a prevalent opinion that the negro has a longer heel than the white man; but an examination of a series of calcanea in both races proves this to be an error. Professor Flower in his lectures on the Comparative Anatomy of Man, shows that the lengthening in the negro is only *apparent* and due to the smallness of his calf and the slenderness of the tendo-Achillis immediately above the heel.

We must examine six different aspects on the os calcis.

SUPERIOR
ASPECT.

Its superior aspect presents the two surfaces which support the astragalus. Of these, the posterior is convex and larger than the anterior, which is concave, long and narrow, and supported by the 'sustentaculum tali' (presently to be described). The plane of both these surfaces is horizontal *transversely*, the better to support the weight, but, like those of the astragalus, they slope a little, so that the weight is transmitted obliquely downwards and forwards upon the arch of the foot. Observe the groove between the articular surfaces for the attachment of the interosseous ligament: this groove makes, with the astragalus, a complete tunnel shown in the woodcut (fig. 60).

If a perpendicular section be made through the os calcis, it shows that the compact wall is thickest at the articular surfaces for the astragalus; and that, from these, the principal septa of the cancelli radiate towards the back and under part of the bone; that is, precisely in the line of pressure.

ANTERIOR
ASPECT.

The anterior end presents a concave vertical surface, which articulates with the cuboid bone. The edge of this surface projects a little, superiorly; and the projection deserves notice, chiefly because it is in the way in the

performance of 'Chopart's'* operation. In some instances it supports a third articular facet for the astragalus (see p. 211). The rough tubercle, on the dorsal surface of the anterior end, gives origin to the 'extensor brevis digitorum.'

POSTERIOR
ASPECT.

The posterior end or 'great tuberosity,' forms the heel. The lower rough part indicates the insertion of the 'tendo-Achillis'; while the smooth part above indicates the position of the bursa between the tendon and the bone.

EXTERNAL
ASPECT.

The external surface is broad, flat, and nearly subcutaneous. Rather in front of the middle, is a tubercle (peroneal tubercle) which serves to keep the peroneal tendons in place, that of the 'peroneus brevis' being above, that of the 'peroneus longus' below the tubercle. Behind this tubercle is, generally, another, much smaller, for the attachment of the external lateral ligament of the ankle.

INTERNAL
ASPECT.

The internal surface presents a concavity for the safe transmission of the plantar vessels and nerves. At its upper part is the process termed the '*sustentaculum tali*,' which helps to support the head of the astragalus, shelters the plantar vessels and nerves, and gives attachment to the calcaneo-scaphoid ligament and to some fibres of the internal lateral ligament of the ankle. There is a deep groove along the under surface of this process for the tendon of the 'flexor longus pollicis.'

INFERIOR
ASPECT.

The inferior or plantar surface presents at its back part two tubercles, of unequal size, the internal being much the larger. They are the only parts of the os calcis which touch the ground. They serve for the origin of muscles, and for the attachment of the strong plantar fascia which protects the sole of the foot. There is also another tubercle forwards for the attachment of the calcaneo-cuboid ligament. Thus, there are three exceedingly strong ligaments attached to the os calcis for the preservation of the arch of the foot—1, the plantar fascia (which acts as a ligament); 2, the calcaneo-scaphoid

* Chopart's operation consists in the removal of all the bones of the foot, except the os calcis and astragalus.

ligament beneath the head of the astragalus ; and 3, the calcaneo-cuboid.

The muscles arising from the os calcis are as follows:— ‘Abductor pollicis,’ ‘abductor digiti minimi,’ ‘flexor brevis digitorum,’ ‘flexor accessorius’ (two heads), and ‘extensor brevis digitorum.’ The ‘tendo-Achillis’ is the only insertion ; unless we include that of the little ‘plantaris,’ on the inner side of the tendo-Achillis, and a few fibres from the tibialis posticus into the ‘sustentaculum tali.’

OSSIFICATION.

The os calcis has a single centre of ossification for the great mass of the bone, which appears about the seventh month, and an epiphysis for the great tuberosity. The nucleus of the epiphysis appears about the tenth year. The epiphysis unites to the bone about the sixteenth. It represents, according to some anatomists, the pisiform bone of the wrist.

CONNECTIONS.

The os calcis articulates with two bones, the astragalus and cuboid.

OS SCAPHOIDES.

SITUATION.

The scaphoid bone, so named from its boat-like form, is situated on the inner side of the tarsus. It presents, *posteriorly*, a concave oval surface (the narrow end being placed internally), which forms part of the socket for the head of the astragalus. *Anteriorly*, it has three articular facets for the three cuneiform bones. These facets are not all on the same plane or of the same shape : the inner is the largest, it articulates with the inner cuneiform : the middle and the outer facets are triangular with the apices below, to fit the middle and outer cuneiform. *Externally*, it has sometimes a small facet which articulates with the cuboid bone. *Internally*, it has a very prominent *tubercle*, which projects on the inner side of the foot, and gives advantageous insertion to the tendon of the ‘tibialis posticus,’ which turns the foot inwards. This tubercle is the best guide to the joint behind it, in the performance of

Chopart's operation. The lower part of the scaphoid is very rough for the attachment of the calcaneo-scaphoid ligament.

DISTINCTION BETWEEN RIGHT AND LEFT.

If the bone be held in its natural position, that is, with the cup backwards, and convex surface upwards, the broader end of the cup will be on the side to which the bone belongs.

OSSIFICATION.

It has a single centre, which appears about the fourth year.

CONNECTIONS.

The scaphoid articulates with four bones, and sometimes five; the fifth being the cuboid.

OS CUBOIDES.

SITUATION.

The cuboid bone is situated on the outer side of the tarsus, and is wedged in between the os calcis and the fourth and fifth metatarsal bones. Observe that the *base* of the wedge is turned towards the cuneiform bones, so that the pressure in the arch of the foot may be properly distributed. Suppose, for a moment, the base were turned the other way, would not the lateral thrust from the external cuneiform bone force the cuboid out of the arch, and the falling of the arch be the consequence?

SURFACES.

Its *posterior* surface is slightly concave from above downwards, and convex from side to side, to articulate with a corresponding surface on the os calcis. Observe that the plane of this joint is the same as that between the scaphoid and astragalus. Hence partial amputation of the foot (Chopart's operation) here is easy. But it cannot be done at one stroke of the knife, because the inner corner of the cuboid projects a little beneath the os calcis, to prevent it being dislocated upwards.

Its *anterior* surface has two smooth facets, the inner nearly square, the outer triangular, for the support of the fourth and fifth metatarsal bones.

Its *internal* surface articulates with the third or outer cuneiform, by a flat oval surface, and, generally, with the scaphoid.

Its *inferior* surface is traversed by a deep groove which runs

obliquely inwards and forwards and lodges the tendon of the 'peroneus longus.' The prominent ridge behind the groove, and the rest of its under surface, give attachment to the calcaneo-cuboid ligament. Observe near the posterior part of this ridge a small smooth facet (crusted in the recent state with cartilage), which articulates with the 'sesamoid' bone in the tendon that lies in the groove.

OSSIFICATION.

The single nucleus of the cuboid bone appears at birth.

CONNECTIONS.

The cuboid articulates with four bones—the os calcis,—the outer cuneiform, and the fourth and fifth metatarsals—and sometimes with a fifth, namely, the scaphoid.

The cuboid gives origin to parts of two muscles in the sole—the 'adductor pollicis,' and the 'flexor brevis pollicis.' Remember that the adductor pollicis arises, not immediately from the bone, but from the fibrous sheath which bridges over the groove for the peroneus longus.

DISTINCTION
BETWEEN RIGHT
AND LEFT.

Hold the bone in its natural position, i.e. with the groove downwards, and the articular surface for the os calcis backwards: the groove will be on the side to which the bone belongs.

OSSA CUNEIFORMIA.

POSITION.

The cuneiform or wedge bones are placed at the front part of the tarsus, and are named the 'internal,' 'middle,' and 'external'; or first, second, and third, according to their position. Behind, they articulate with the scaphoid; in front with the three inner toes, respectively. The bases of the middle and external are towards the dorsum of the foot, but the base of the internal is turned towards the sole, in order to form one of the buttresses of the transverse arch of the foot.

INTERNAL
CUNEIFORM.

The first or internal cuneiform is the largest, because it supports the great toe. Anteriorly, it articulates with the metatarsal bone of the great toe by a slightly

convex, kidney-shaped surface, with the long diameter vertical. Inferiorly, the thick base projects into the sole considerably below the other cuneiform bones in order to give broad insertion to the tendons of the two muscles which turn the sole of the foot inwards, namely, the 'tibialis anticus' and 'posticus.' Externally, it is slightly concave, and articulates along its upper and posterior margins with the second cuneiform bone and the second metatarsal bone: internally, it is convex, and has a little smooth surface over which the tendon of the 'tibialis anticus' plays. Posteriorly, it articulates with the scaphoid by a concave surface, wider below than above.

Thus it articulates with four bones, namely—the scaphoid, the middle cuneiform, and the two inner metatarsals.

DISTINCTION
BETWEEN RIGHT
AND LEFT.

Hold the bone with the base downwards and the kidney-shaped surface forwards: the concave side will look towards the foot to which the bone belongs.

MIDDLE
CUNEIFORM.

The second or middle cuneiform bone is not only the smallest of the three, but does not project so much as the others; consequently the second metatarsal bone, which it supports by a triangular surface, is more deeply set in the tarsus than the other metatarsals. This is a point to be remembered in removing the metatarsal bones (Hey's operation). Posteriorly, it articulates with the scaphoid by a triangular surface with the apex below. It has on each side an articular facet for the adjoining wedge bones. The external facet, slightly concave, runs vertically along its posterior half in correspondence with the external cuneiform. The internal facet, slightly convex, skirts its superior and posterior borders; thus presenting a horizontal and a vertical portion, in exact correspondence with the marginal surface of the internal cuneiform. It is one of the peculiarities of these wedge bones of the foot, that intervals are left between their sides, for the attachment of the interosseous ligaments which fasten the bones together.

CONNECTIONS.

The middle cuneiform articulates with four bones—the scaphoid, outer and inner cuneiform, and the second metatarsal.

DISTINCTION BETWEEN RIGHT AND LEFT. Hold the bone with the apex downwards, and the narrowest side of the base forwards: the concave side, which has the vertical articular surface only, will look towards the foot to which it belongs.

EXTERNAL CUNEIFORM. The third or external cuneiform bone articulates, externally, with the cuboid by a flat oval facet, and with the inner corner of the fourth metatarsal bone; internally, with the middle cuneiform and the second metatarsal; posteriorly, with the scaphoid; anteriorly, it supports the third metatarsal on a triangular surface: thus it articulates with six bones. Notice, especially, the extent to which it juts forwards between the second and fourth metatarsal bones, so that it helps to support three metatarsals, just as the os magnum of the wrist supports three metacarpals (p. 164).

The flexor brevis pollicis partly arises from the under surface of the external cuneiform; and some of the fibres of the tendon of the tibialis posticus are inserted into it.

DISTINCTION BETWEEN RIGHT AND LEFT. Hold the bone with the apex downwards, and the triangular articular surface forwards: the flat oval facet for the cuboid side will look towards the foot to which it belongs.

ARTICULATIONS OF TARSAL BONES. Look once more at the bones, and remember that the astragalus articulates with four bones; the os calcis with two; the scaphoid with four (sometimes five); the internal cuneiform with four; the middle cuneiform with four; the external cuneiform with six; the cuboid with four (sometimes five, the fifth being the scaphoid).

OSSIFICATION OF THE TARSAL BONES. Each bone of the tarsus has one centre of ossification, except the os calcis, which has two. The os calcis begins to ossify about the sixth month of foetal life; the astragalus about the seventh month; the cuboid about birth; the external cuneiform about the first year after birth; the middle and internal cuneiform and scaphoid about the third or fourth year.

The second centre of the os calcis is at the back part of it. It appears about the tenth year, and joins the rest of the bone about puberty. It represents the pisiform bone of the wrist.

METATARSUS.

GENERAL
DESCRIPTION.

The five metatarsal bones are named the first, second, third, etc., counting from the inner side. The first is the shortest and by far the strongest, since it supports the great toe. The second is the longest; and from this the third, fourth, and fifth gradually decrease in length. All are slightly arched from before backwards; in addition to this, the three outer incline a little sideways towards the great toe. The outer sides of their shafts are flattened, the inner are more convex. The spaces between them are termed the 'interosseous spaces,' and gradually decrease in size towards the outer side. As the metatarsal bones are 'long' bones, we speak of their shafts and their articular ends; the upper end being termed the 'base,' and the lower the 'head' of the bone.

Like the corresponding bones in the hand, the shafts of the metatarsal bones are more or less triangular, for the convenient lodgment of the interosseous muscles, and they gradually taper from their upper ends.

BASES OR
UPPER ENDS.

Their *bases* articulate with the second row of the tarsus, and, laterally, with each other; that of the first excepted. Observe that the line of the tarso-metatarsal articulations would be a tolerably even curve, but for the second metatarsal, which is jammed into a recess between the cuneiform bones. Thus the second metatarsal is firmly locked in like the second metacarpal.

HEADS OR
LOWER ENDS.

Their *heads*, which are much smaller than those of the metacarpal bones, are convex, to fit into the cups of the first phalanges; they are grooved above for the attachment of ligaments, and have lateral tubercles towards the dorsal surface also for the attachment of ligaments.

The convexity of the head of each metatarsal extends well downwards towards the sole of the foot—that is, in the direction of flexion, and terminates below in two points which we will call the 'condyles.' Now the external condyle is always the more prominent, and a well-marked ridge runs between it and the shaft. Hence, when a metatarsal bone is held in its natural posi-

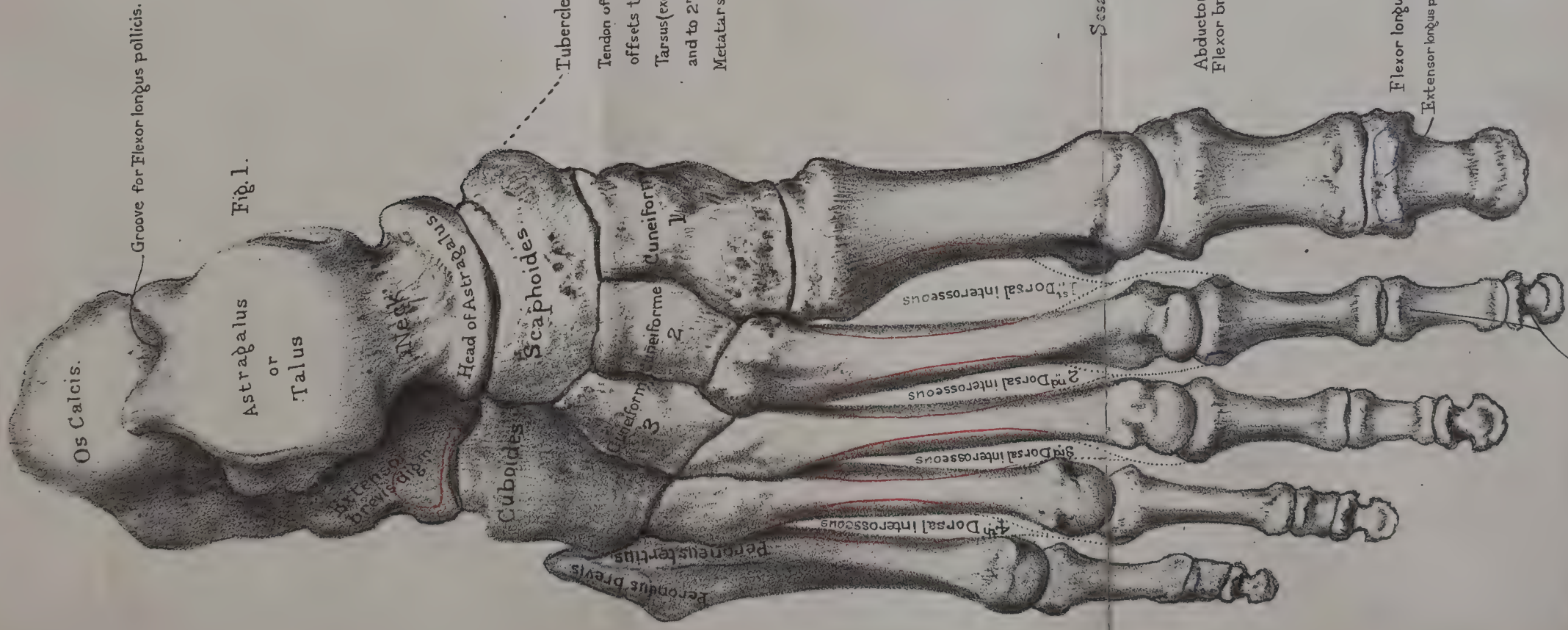


Fig. 1.

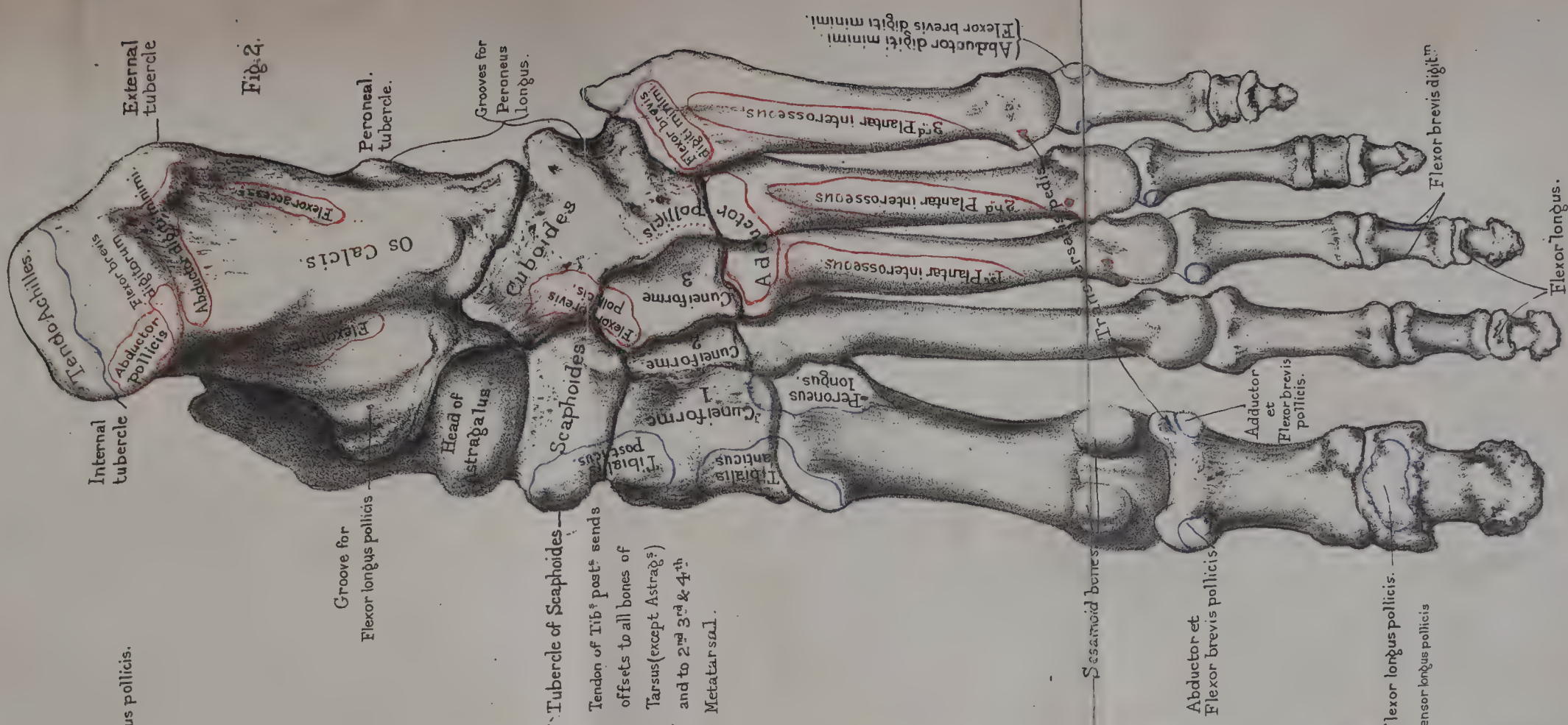
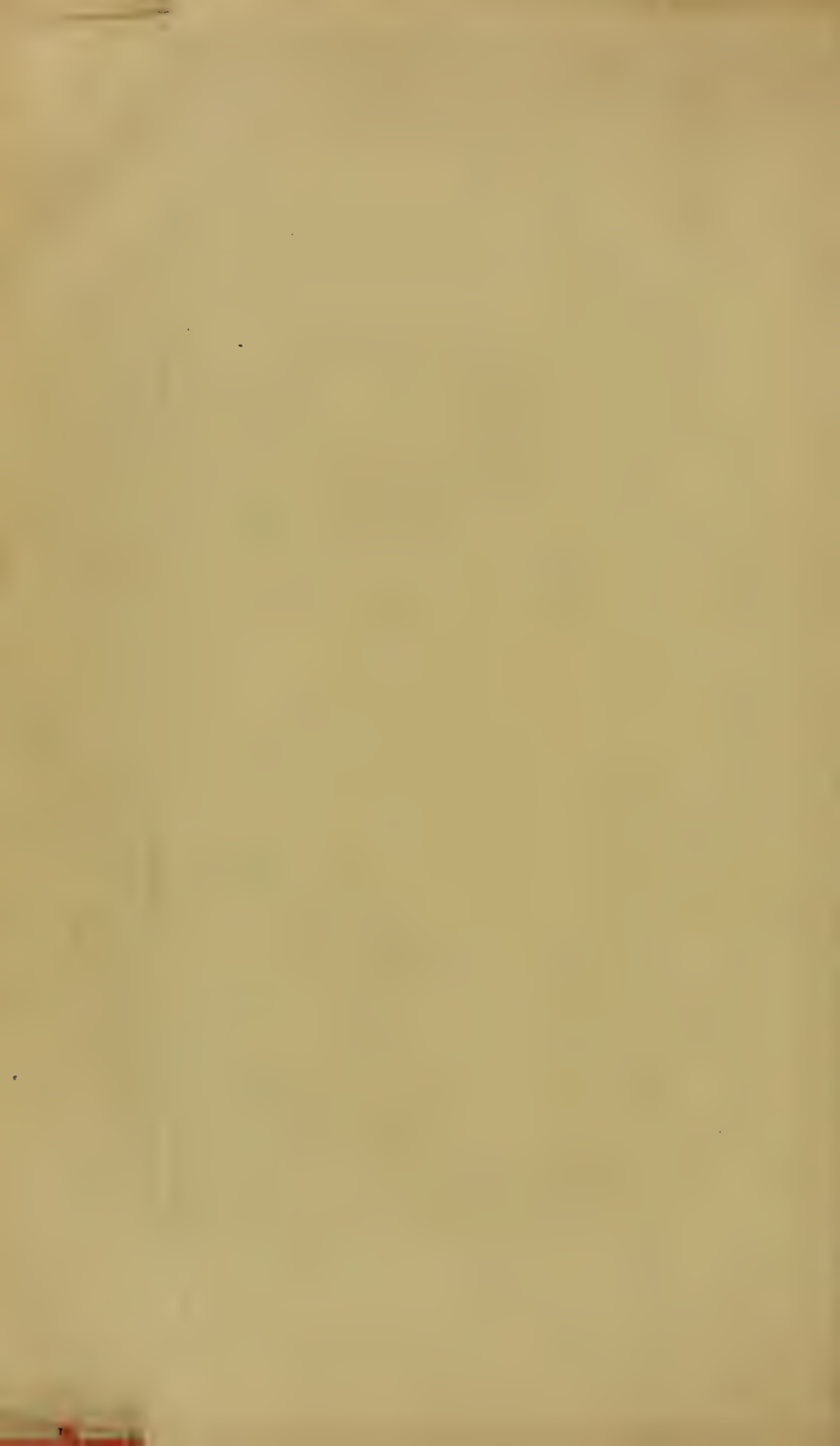


Fig. 2.



tion, with the head forward, and the dorsum of the shaft upwards, the more prominent condyle will be on the side to which the bone belongs.

FIRST META-TARSAL.

The excessive strength and size of the first metatarsal bone which supports the great toe, is peculiar to man. It is the chief support upon which the body is raised by the great muscles of the calf. Its base presents a kidney-shaped surface, which articulates exclusively with the internal cuneiform bone; and there is an impression on the outer side of its plantar aspect, indicating the insertion of the 'peroneus longus.' Its head is remarkably broad, to support the ball of the great toe, and has on its under surface two grooves (separated by a ridge) for the play of the two sesamoid bones.

FIG. 61.

I.



BASE OF FIRST RIGHT METATARSAL. OUTER SIDE.

RIGHT OR LEFT?

Hold the bone in its natural position, with the base towards you: the concave side of the kidney-shaped surface, and the impression for the peroneus longus (fig. 61) will look towards the foot to which it belongs.

SECOND METATARSAL.

The second metatarsal bone, the longest of all, may be known by its triangular surface at the base for the middle cuneiform bone, a small lateral facet for the inner cuneiform, and four lateral facets on its outer side; namely, two* for the outer cuneiform, and two for the third metatarsal bone.

FIG. 62.

II.



INNER SIDE.

FIG. 63.

II.



OUTER SIDE.

BASE OF SECOND RIGHT METATARSAL.

RIGHT OR LEFT?

Hold the bone with the base towards you, and in its natural position: the four lateral facets will be on the side to which the bone belongs (fig. 63).

* These facets are sometimes joined so as to form a vortical linear surface, but generally the upper are separated from the lower by a gap for the interosseous ligament.

FIG. 64.
III.INNER SIDE.
BASE OF THIRD RIGHT METATARSAL.FIG. 65.
III.

OUTER SIDE.

THIRD
METATARSAL.

The third metatarsal bone may be known by its having two articular facets on the inner side of the base, and one on the outer side.

Hold the bone with the base towards you :

the single lateral facet will be on the side to which the bone belongs (fig. 65).

FOURTH
METATARSAL.

The fourth metatarsal bone may be known by its square tarsal surface for the cuboid, and a single facet on each side (fig. 66, 67). The inner facet is, as a rule, divided by a slight ridge into an anterior and a posterior part.*

Hold the bone with the base towards you : the most prominent angle at the base

will point to the foot it belongs to.

FIG. 66.
IV.

INNER SIDE.

FIG. 67.
IV.

OUTER SIDE.

BASE OF FOURTH RIGHT METATARSAL.

RIGHT OR LEFT?

FIG. 68.
V.

INNER SIDE.

FIG. 69.
V.

OUTER SIDE.

BASE OF FIFTH RIGHT METATARSAL.

FIFTH
METATARSAL.

The fifth metatarsal bone cannot be mistaken, in consequence of the great projection on the outer side of its base. The use of this projection is to give attachment to ligaments, and to the tendon of the peroneus brevis. The peroneus tertius is inserted on the dorsal aspect of the base. The surface of articulation with the cuboid slants towards the ball of the great toe. There is a round lateral facet for the fourth metatarsal.

Hold the bone with the base towards you : the projection from it will be on the side to which the bone belongs (fig. 69).

* The posterior being for the outer cuneiform. But the fourth metatarsal does not

AGREEMENT BE-
TWEEN METATAR-
SALS AND META-
CARPALS.

It may be well to remind the reader that there is a remarkable agreement in the majority of cases in the number of bones with which corresponding metatarsals and metacarpals articulate at their bases. Thus, the base of the first, in each case, articulates with one bone—that of the second with four—that of the third with three—that of the fourth with three—and that of the fifth with two. This agreement points to a common plan in the development of the hand and foot.

OSSIFICATION.

Each metatarsal bone has two centres of ossification; one for the shaft, the other for the head. The first metatarsal, however, has its terminal epiphysis *not* at the head, but at the base, which is precisely the case with the metacarpal bone of the thumb. The epiphyses appear about the fourth year, and unite to the shafts about the eighteenth.

PHALANGES OF
THE TOES.

The phalanges of the toes resemble in number and plan the corresponding bones in the hand, which we have already described. The second phalanges are very short. Like the thumb, the first, or great toe has only two phalanges. That which is absent is the second phalanx. This is the case throughout the whole mammalian class, provided it supports a nail, a hoof, or a claw. In subservience to its function of supporting the body, the great toe is not only the largest but, in most instances, the longest of the toes. The third toe is the representative of the chief part of the hind foot of the horse. The last two phalanges of the little toe are generally ankylosed in adults, in consequence of being cramped by tight shoes: so different from that free spreading of the toes which nature intended.

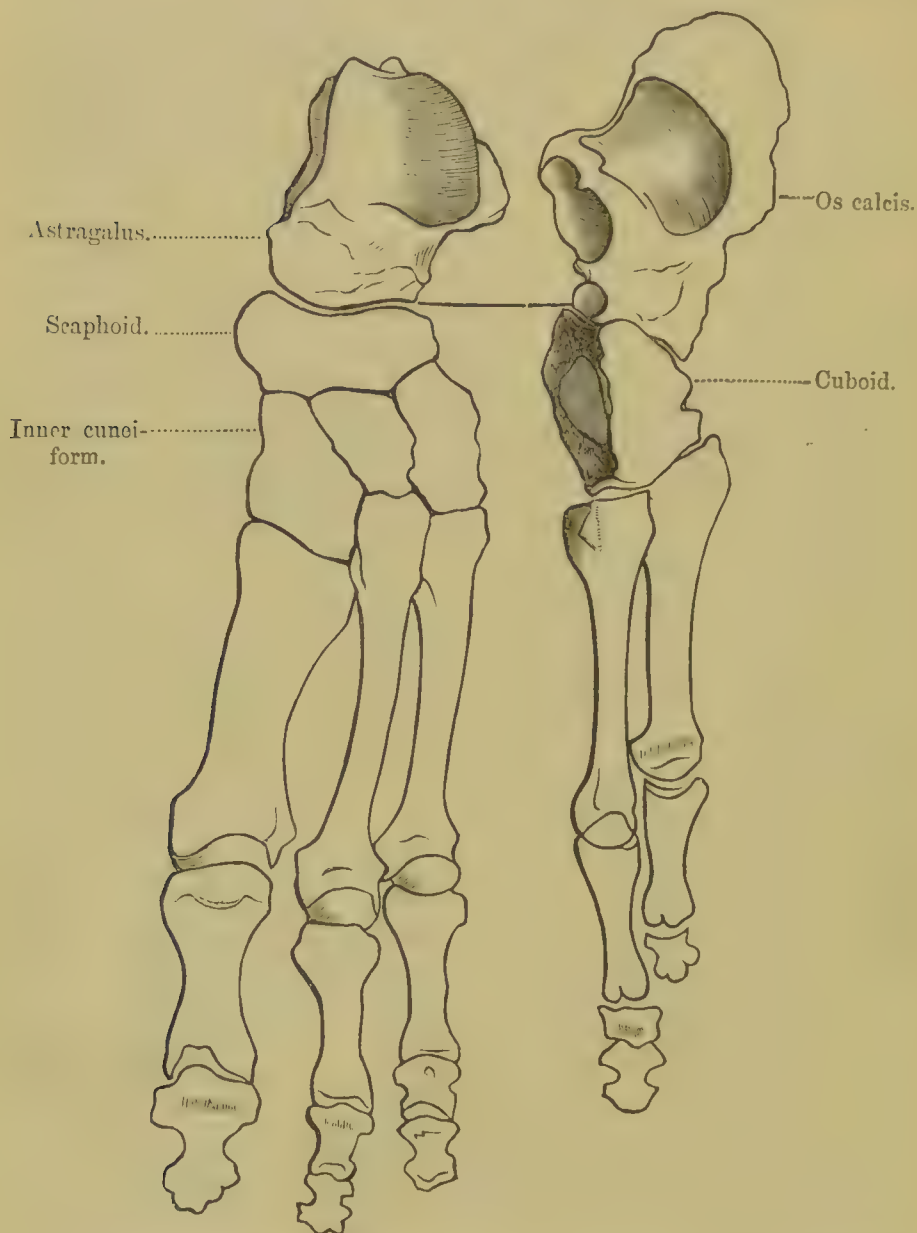
SESAMOID BONES.

There are two sesamoid bones which play in two grooves beneath the head of the first metatarsal bone. They act like little ‘patellæ,’ and increase the leverage of the muscles which work the great toe (see p. 170). Very exceptionally similar bones are met with in the corresponding joints of other toes.

always touch the outer cuneiform. This variation, seen in several specimens in the stores of the Museum of the Royal College of Surgeons, is recognised by Sappey.

The following outline, * taken from a preparation, is made to show the sequence of the bones which form the inner and the outer sides

FIG. 70.



of the longitudinal arch of the foot. On the inner side are the astragalus, the scaphoid, and the three cuneiform bones supporting the

* We are indebted for this outline to Mr. Keetley, Assistant-Demonstrator of Anatomy at St. Bartholomew's Hospital.

three inner metatarsals. On the outer side are the os calcis, the cuboid and the two outer metatarsals. By putting the two sides together, it is easy to study and recollect their relative bearings.

OBSERVATIONS ON THE FOOT AS A WHOLE.

GENERAL OBSERVATIONS ON THE FOOT.

The knowledge of the individual bones will be of little practical use, unless the skeleton of the foot be studied as a whole.

ARCHES OF THE FOOT.

The foot is a combination of numerous small bones, adapted and connected so as to form certain strong and, at the same time, elastic arches.

LONGITUDINAL ARCH.

The principal arch is in the antero-posterior or long axis of the foot. This 'longitudinal arch' has to bear the weight of the body erect. It is supported, behind, by the tuberosities of the os calcis; and in front, by the distal ends of the metacarpal bones. Its inner side is much higher than the outer, and is formed by the astragalus, the scaphoid, the three cuneiform and three inner metatarsal bones. This is well seen in fig. 70. The outer side of the arch is much lower than the inner, and is formed by the os calcis, the cuboid, and the two outer metatarsal bones. It is supported mainly by a strong ligament termed the 'calcaneo-cuboid.'

TRANSVERSE ARCH.

Besides the longitudinal arch there is another in the transverse direction. This is most marked over the instep; that is, its greatest convexity is across the cuneiform and the cuboid bones. Its inner side is much thicker than the outer.

YIELDING OF THE ARCHES.

When we stand, not only does the *longitudinal* arch of the foot yield, but the *transverse* arch yields also. The wedge bones and the metatarsals are connected by interosseous ligaments, which, being slightly elastic, give a little, and thereby increase the transverse breadth of the foot. A transverse section across the instep, that is, through the wedge bones, shows that they are shaped, not like the stones of a bridge, as in fig. 71, but as represented in fig. 72.

FIG. 71.



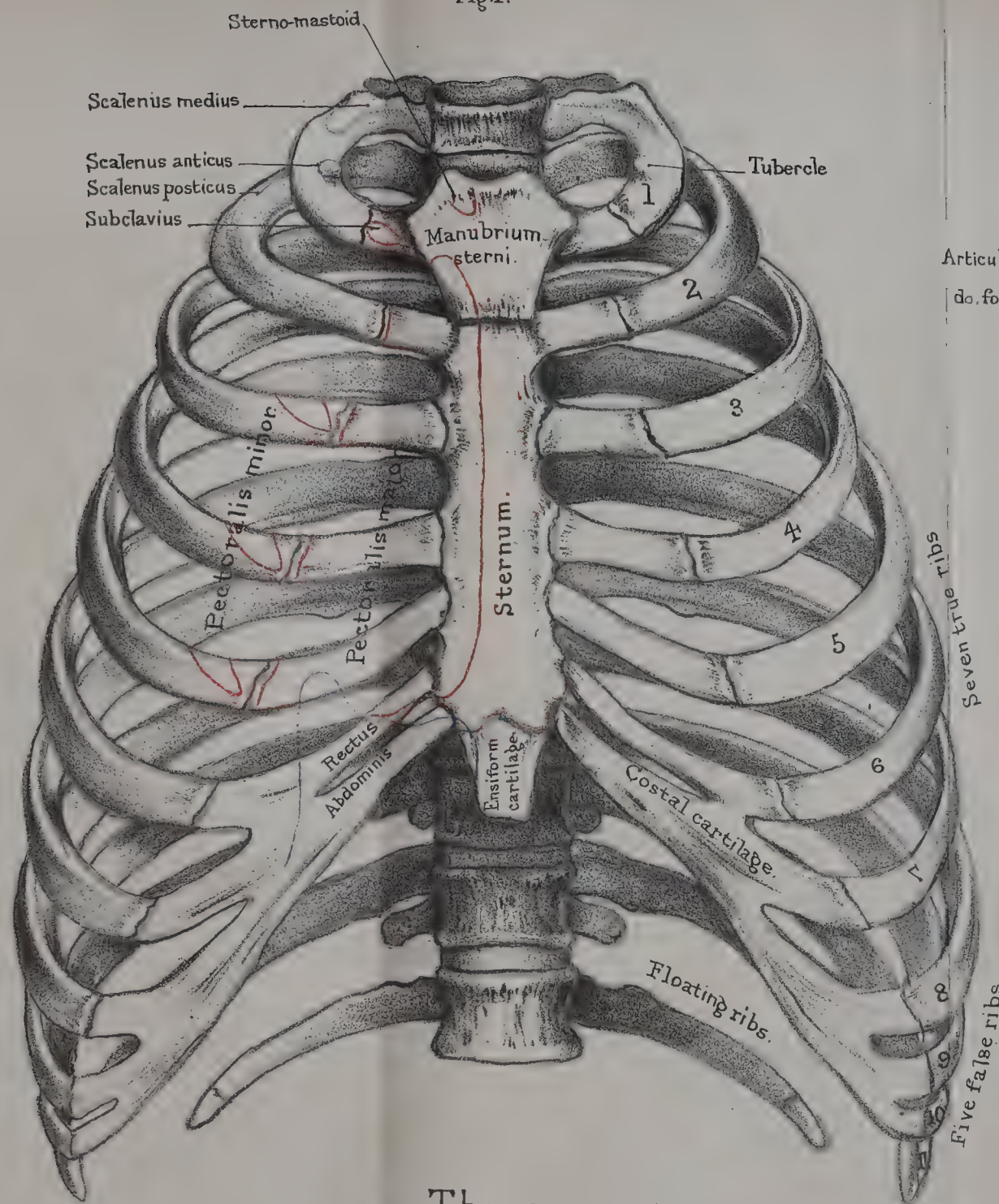
THE THORAX.

(PLATE XLVII.)

GENERAL DESCRIPTION. **THE THORAX** is the framework which contains the heart and lungs. The ribs, with their cartilages, describe a series of arcs, successively increasing in length as far as the seventh, and form, with the spine and sternum, a barrel of a somewhat conical shape, much broader from side to side than from before backwards. The lower aperture or base of the cavity is open in the skeleton, but closed in the recent subject by a thin flat muscle, called the ‘diaphragm,’ which separates the chest from the abdomen, and has openings for the passage of the alimentary canal and the great blood-vessels. This muscular partition is not flat, but arched, so that it forms a vaulted floor for the chest. By its property of alternately rising and falling, it can increase or diminish the capacity of the chest. The spaces between the ribs are filled by the intercostal muscles. In each space there are two layers which cross like the letter X: the outer layer runs downwards and forwards: the inner, upwards and forwards.

Such, in outline, is the framework of the chest. Its walls are made up of different structures—bone, cartilage, and muscle, put together so as to answer two apparently incompatible purposes. By their solidity and elasticity they protect the important organs contained in the chest; and by their power of alternately dilating and contracting, they serve as the mechanical agents of respiration. They can enlarge the cavity of the chest in three directions: in *height*, by the descent of the diaphragm; in *width*, by the turning outwards of the ribs; in *depth*, by the raising of the sternum.

Fig. 1.



Thorax.

Drawn on Stone by T. Godart

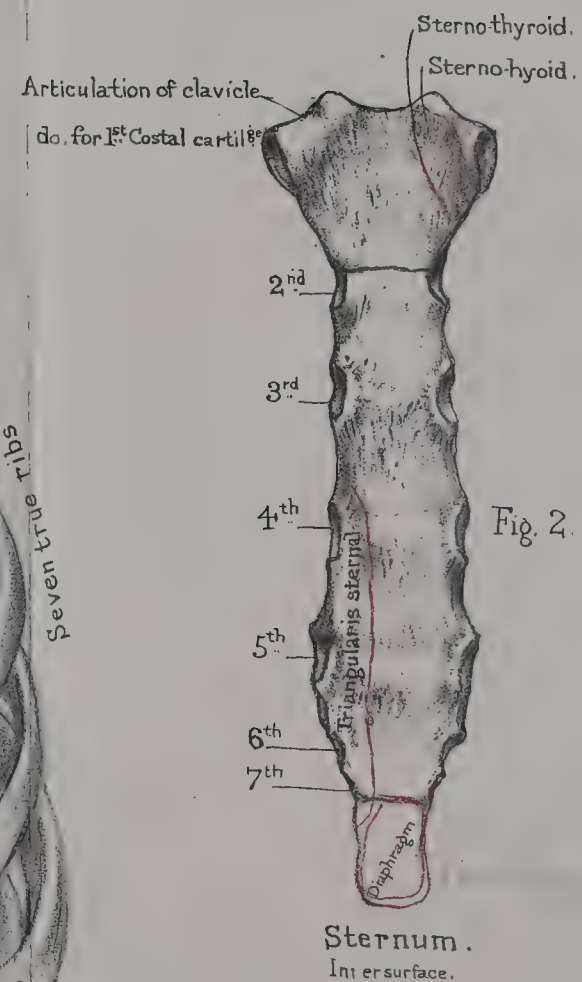
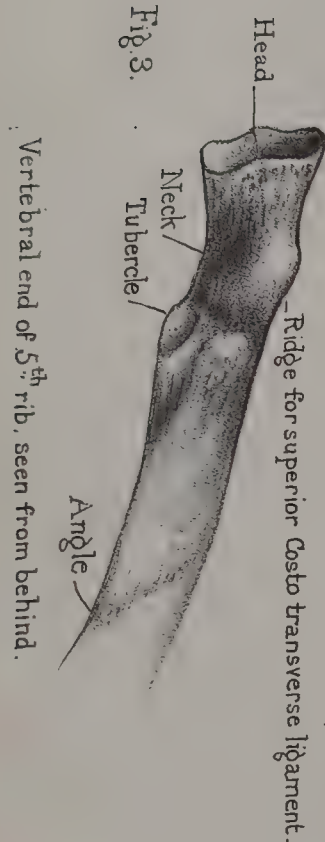


Fig. 2.

Sternum.
Internal surface.

Fig. 3.



Vertebral end of 5th rib, seen from behind.

From nature by L. Holden

Printed by W. West & Co.

THE STERNUM.

(PLATE XLVII.)

POSITION.

The sternum (στέρνον, the breast) is a long flat bone, situated in front of the chest, for the support of the ribs and the clavicles. In the adult male, it is from six to seven inches long: rather less in the female. Observe that its direction is not perpendicular, but that it slants forwards, so as to make more room for the heart and lungs. It is much broader and thicker at the upper end (manubrium),* because this has to support the clavicles.

TRANSVERSE
LINES AND
MANUBRIUM.

We notice upon the sternum four faintly-marked transverse lines, which are traces of the original division of the bone into five pieces. The most conspicuous of these lines corresponds with the insertion of the second costal cartilage; that is, at the junction of the manubrium with the second piece. This line is an important guide to the second rib. The 'manubrium' or 'presternum' has a notch on the top (interclavicular notch), so as not to press on the trachæa. On either side of it is an oblong articular surface for the clavicle. In the dry bone, this surface looks flat; but in the recent state, the incrusting cartilage makes it somewhat saddle-shaped, that is, concavo-convex. This kind of joint permits the clavicle to rotate nearly as freely as the thumb on the trapezium. Although the end of the clavicle is so much larger than the surface on which it rotates, yet dislocation of it is exceedingly rare, owing to the great strength of the ligaments. To break the clavicle is much easier than to dislocate it (see p. 140). ~~†~~ *†*.

MESOSTERNUM
AND NOTCHES.

Each border of the middle division of the sternum ('mesosternum') has seven notches in it for the reception of the cartilages of the seven true ribs. All, except the first, are situated at the places where the original pieces

* The sternum was compared by the ancients to a sword; the broad part was called 'manubrium,' the middle part 'mucro,' and the cartilage at the end the 'xiphoid' or 'ensiform' cartilago. (*gladius*)

of the bone unite. In some instances there is a hole in its lower part.

ENSIFORM
CARTILAGE.

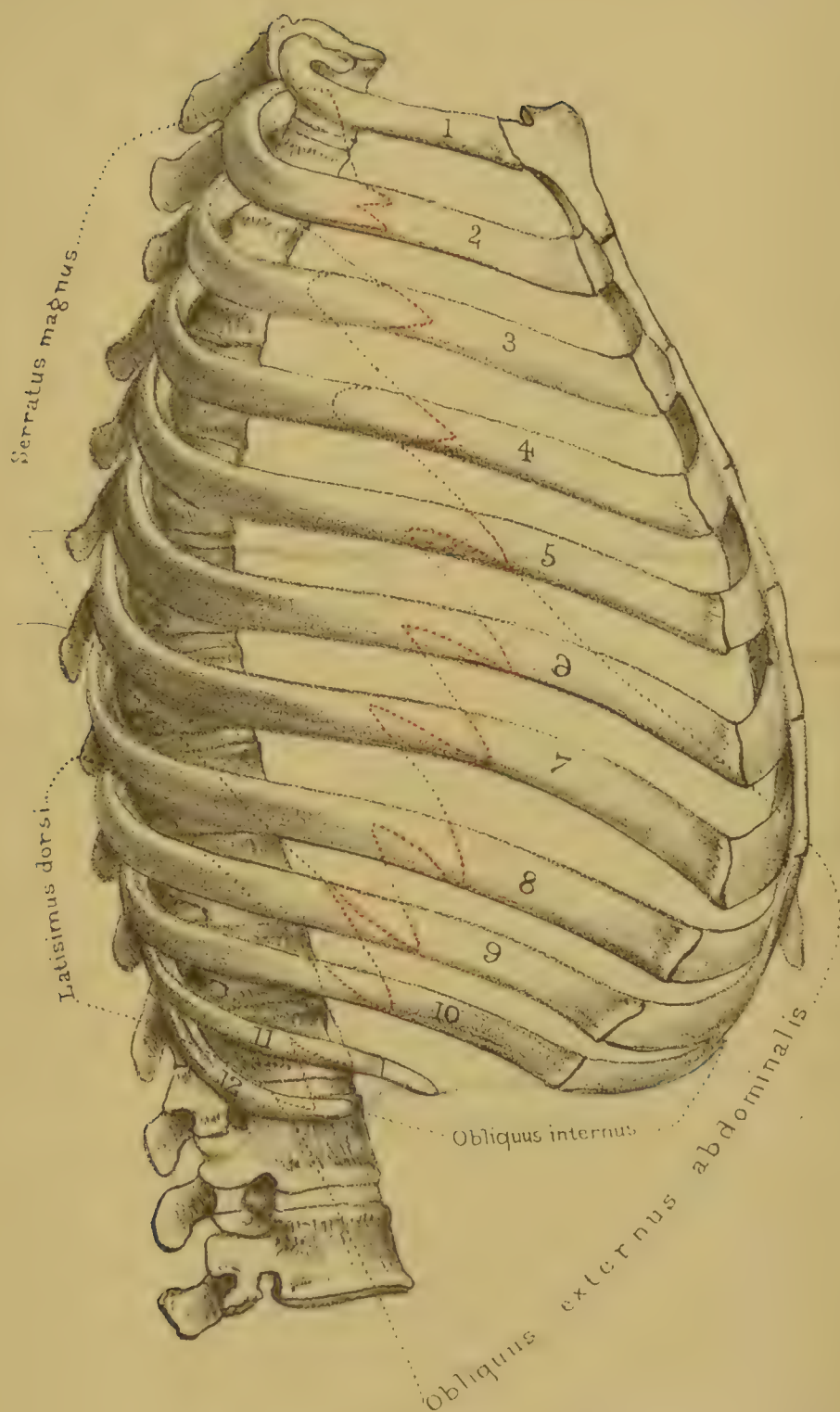
The ensiform cartilage (or 'xiphisternum') at the lower end of the sternum generally remains unossified, even at a great age. Its length and shape vary much in different persons. Sometimes it is bent forwards, or, it may be, backwards, and this especially in workmen who hold tools against the pit of their stomach. Occasionally it is forked at the end. It gives attachment to a narrow aponeurotic band, termed the 'linea alba,' which descends along the middle line of the abdomen to the symphysis pubis, and is the answerable part of the sternum.

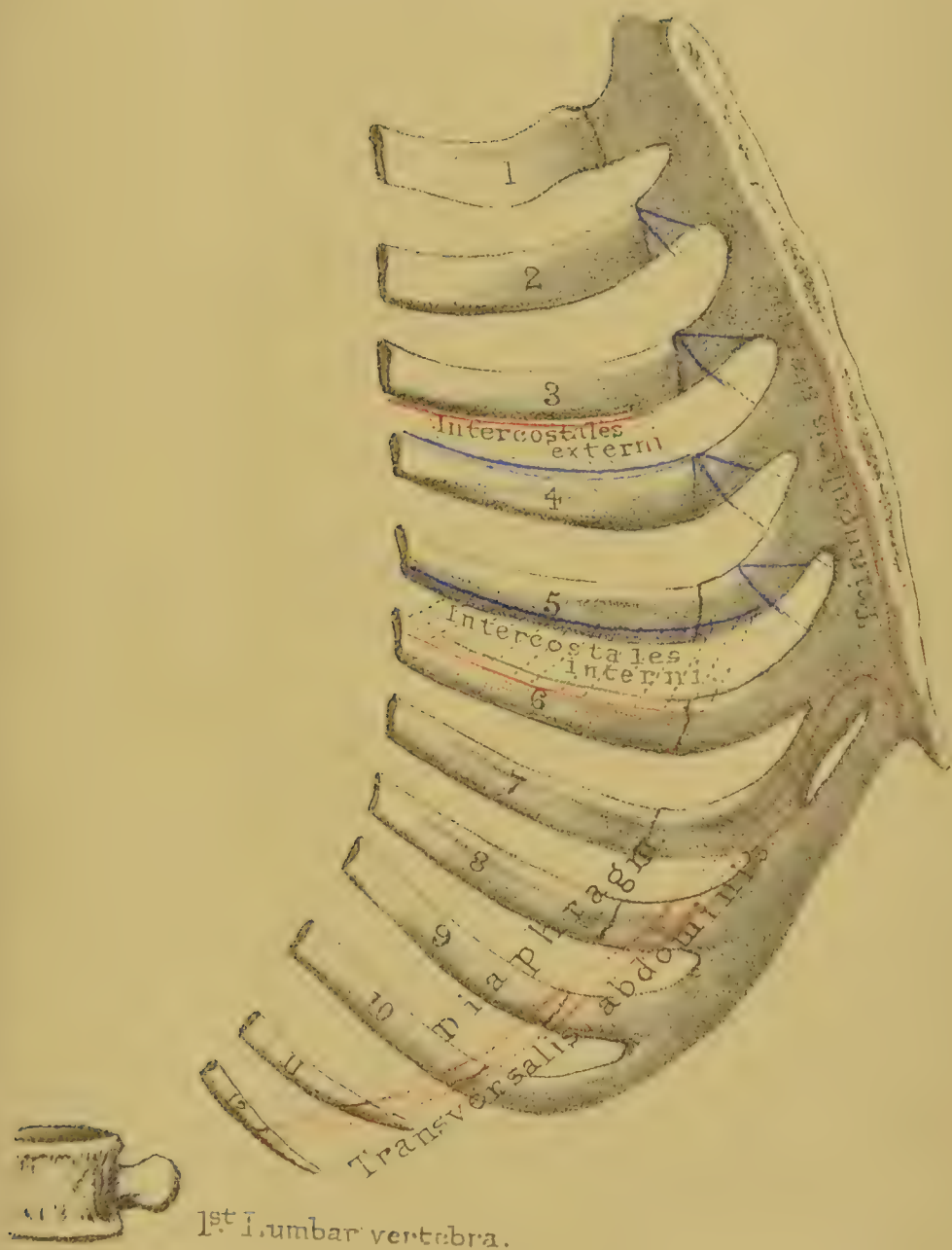
The anterior surface of the sternum gives origin to the 'sternomastoid' and the 'pectoralis major.' The posterior surface gives origin to the 'sterno-hyoid' and 'sterno-thyroid' and to the 'triangularis sterni.' The posterior surface of the ensiform cartilage gives origin to the 'diaphragm.'

OSSIFICATION OF
THE STERNUM.

Until the middle of foetal life, the sternum is all cartilage. It is ossified from five centres,* not simultaneously, but successively from above downwards, opposite the intercostal spaces. The five bones, thus formed, ultimately coalesce, the lower first, and so on upwards—the reverse of the order in which they were ossified. Thus the fifth unites to the fourth about puberty; the fourth to the third about the age of twenty or twenty-five; the third to the second about thirty-five or forty; the second rarely unites to the first, or, if so, only in advanced age; and even then there is only a thin layer of bone externally; the cartilage in the centre still remains. The reason why the union between the first and second bones of the sternum remains cartilaginous is to permit a certain amount of motion which facilitates respiration. In some subjects the line of junc-

* Exceptions to this rule are frequent. There may be two, three, or more centres for the first bone; and, instead of a single centre, any of the other pieces may have two, placed side by side. The sternum is formed in cartilage along the line where the 'ventral laminae' of early embryonic life unite. Partial failure of this union accounts for the longitudinal cleft occasionally seen in the body of the human sternum; and the appearance of symmetrical points of ossification is explained in the same manner.





tion is very perceptible through the skin, more especially in persons emaciated by disease. It corresponds with the centre of the second rib.

THE RIBS.

(PLATE XLVII.)

NUMBER AND
DIVISION.

There are twelve ribs on each side; the upper seven, the 'sternal,' or 'true ribs,' increase in length from the first, and are fixed to the sternum by their cartilages. The lower five, or 'false ribs,' decrease in length from above downwards, and their cartilages fall short of the sternum. The cartilages of the eighth, ninth, and tenth ribs are connected to that of the seventh. The eleventh and twelfth are free, and are therefore called 'floating' ribs. One sometimes, though rarely, meets with skeletons with thirteen ribs, the thirteenth being a lumbar rib. This is a degradation. The chimpanzee has thirteen ribs, but the same number of vertebræ as man.

GENERAL CHARACTERS
OF A RIB.

As an example of the general characters of a rib, take the fifth or sixth. In the first place, observe that the curve is not uniform. It is more curved towards the vertebral end than elsewhere. Besides which, if laid on a table, the vertebral end will rise. It is plain in the skeleton that the vertebral ends of the ribs are higher than the sternal ends. If both ends had been on the same level, the sternum could not have been raised *forwards* in inspiration.

VERTEBRAL
END OR HEAD.

The vertebral end or 'head' (Plate XLVII. fig. 3) has two oblique surfaces (with an intervening ridge, to which the interarticular ligament is attached), which articulate with the sides of the bodies of two contiguous vertebræ. The lower of these two surfaces is always the larger. The head of the rib is the fulcrum upon which the rib moves, and is wedged in between two vertebræ, because it is less liable to be dislocated than if supported by a single one; and moreover it has the benefit of the elasticity of the intervening fibro-cartilage. This, as Paley

observes, is 'the very contrivance employed in the famous iron bridge at Bishop's Wearmouth.'

NECK.

Next to the head comes the 'neck' of the rib.

This is smooth in front, where it is covered by pleura, but rough behind for the attachment of a ligament (middle

FIG. 73.



DORSAL VERTEBRA WITH RIBS
ATTACHED.

costo-transverse), which connects it to the transverse process by which the rib is supported, as seen in the adjoining cut; again, the neck has a ridge along its upper surface for the attachment of a second ligament (superior costo-transverse), which connects it to the transverse process above it.

TUBERCLE.

External to the neck is the 'tubercle.' It has

a little facet which looks *downwards* and articulates with the transverse process supporting the rib; in front and rather above the facet is the rougher part of the tubercle which gives attachment to a third ligament connecting the rib to the transverse process (posterior costo-transverse).

ANGLE.

External to the tubercle, the rib makes a curve

forwards, forming the 'angle.' Here there is a prominent line which runs obliquely downwards and forwards, and indicates the attachment of muscles, which form the outer border of the 'erector spinæ.' Observe that the distance between the angle and the tubercle increases as we trace the ribs downwards, in order to make room for the great muscle of the spine (erector spinæ). The angle, for obvious reasons, is the strongest part of the rib. It is at the angle, or near it, that the rib breaks when the chest is compressed, for instance, in a crowd. In this kind of fracture—i.e. by *indirect* violence—the broken ends project outwards, and are therefore less liable to injure the pleura. I have seen eight ribs broken, from the second inclusive to the ninth, as the result of a squeeze; all reunited by bone, without injury to the pleura. But in *direct* violence—e.g. a kick by a horse—the rib breaks where it is struck, the broken ends are driven inwards, and consequently are more liable to injure the pleura.

BODY OR SHAFT.

The rest of the rib arching forwards from the angle along the side of the chest is called the 'body' or 'shaft.' It is flattened from above downwards, like a bow. On its inner surface, near the lower border, is a deep groove for the intercostal vessels and nerve. Observe the groove does not extend all along the rib: it begins about the angle, and is gradually lost before we come to the anterior end. The vessels and nerve are safe where they lie in the groove; but between the angle of the rib and the spine, and again in front of the chest, they are liable to be injured through the intercostal spaces. In consequence of this groove, the lower end of the rib is much thinner than the upper, which is thick and rounded. In the groove itself notice the orifices of the numerous canals which transmit blood-vessels into the interior of the rib. The ribs are the most vascular bones in the body: hence the rapidity with which they unite after a fracture.

ANTERIOR END.

Respecting the anterior end, remark that it is rough, and a little excavated to receive the costal cartilage.

PECULIARITIES
OF THE FIRST RIB.

The first, second, tenth, eleventh, and twelfth ribs have peculiarities requiring separate notice.

The plane of the first rib is nearly horizontal. It is the shortest, the most curved, the flattest and broadest of all. Its head has a single articular surface which rests on the first dorsal vertebra. It has the largest tubercle, and this is well supported by the strong transverse process of the first dorsal vertebra. There is scarcely a trace of angle. On its upper surface we may see in a well-marked bone two slight transverse grooves about the breadth of a finger; the subclavian artery lies in the posterior groove as it crosses the rib, the vein passes along the anterior. Against this surface the subclavian artery may be effectually compressed. The grooves are separated on the inner border of the rib by a 'tubercle' denoting the insertion of the 'scalenus anticus.' Behind this is the rough surface for the insertion of the scalenus medius. Lastly, there is no groove for the intercostal artery.

RIGHT OR LEFT?

If you have any difficulty in distinguishing to which side the first rib belongs, hold it so that the

'facet' for the transverse process looks downwards. This rule holds good when applied to all the ribs.

It is an interesting fact, that the compact tissue forming the *concave* margin of the first rib is very much thicker than that on the convex side. The first rib is the strongest of all: it has to support the manubrium sterni and the clavicles, and to protect all the important parts at the base of the neck. Fracture of the first rib is a very rare accident; but, when it does happen, a most serious one, because it is the starting point of all the other ribs in respiration, and because there are so many important vessels and nerves in relation with it.

SECOND RIB.

The second rib has little or no angle, no twist on its axis, and has, near the middle of its outer surface, a rough eminence for the origin of the second and third digitations of the serratus magnus. It has a short groove for the intercostal artery.

TENTH RIB.

The tenth rib has a single 'facet' on the head, for the tenth dorsal vertebra.

ELEVENTH AND TWELFTH RIBS.

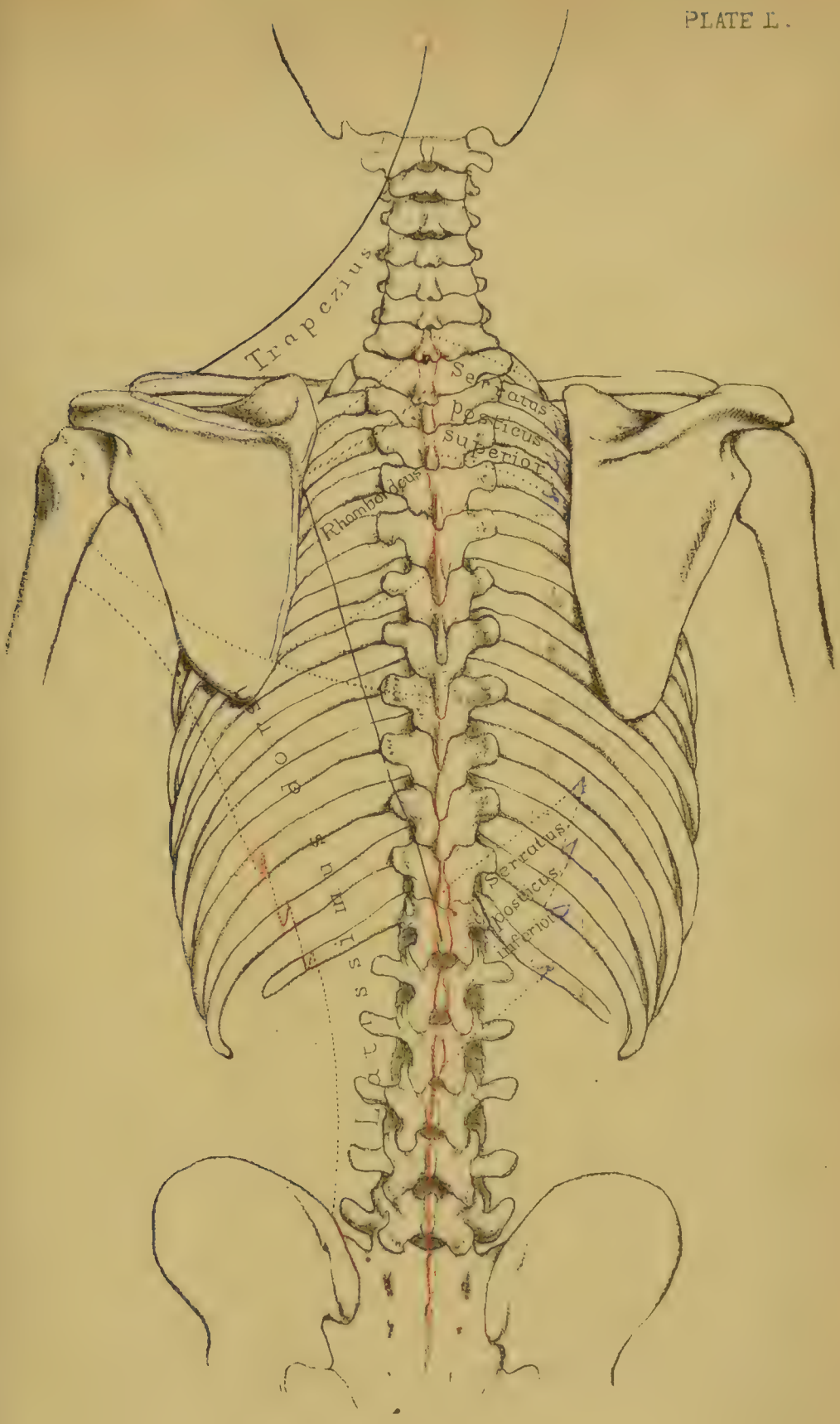
The *eleventh* and *twelfth* ribs being shorter and less perfectly developed, are chiefly distinguished by their negative characters. They articulate with only one vertebra, so that their heads have only one facet, do not touch the transverse processes, and have no tubercle. Each is tipped with cartilage. The eleventh has a trace of an angle and a groove. In the twelfth, angle and groove are imperceptible.

OSSIFICATION.

Ossification begins about the seventh week in the ribs to protect the heart and lungs. There is one 'primary' centre for the body, an epiphysis for the head, and another for the tubercle. These epiphyses appear from the fifteenth to the eighteenth year, and unite with the rest of the bone about the age of twenty-five.

COSTAL CARTILAGES.

Respecting the costal cartilages, remember that the first seven are connected with the sternum. The first cartilage is united directly with the manubrium. The others, from the second to the seventh inclusive, are articulated to the sternum with the intervention of synovial membranes which disappear in old age. The cartilages of the eighth, ninth, and tenth ribs are gradually bevelled off and each joins the costal carti-





lage immediately above it. Moreover, synovial membranes exist between these last-mentioned ribs. The last two costal cartilages do not join those above, but merely cap the eleventh and twelfth ribs. These numerous little articulations, connected with the cartilages, much facilitate the respiratory movements of the thorax.

Observe that the costal cartilages increase in length from above, to allow the requisite play of the ribs in respiration. Their great elasticity answers a double purpose. 1. They act as mechanical agents of expiration by depressing the ribs after they have been raised by muscular action. 2. They enable the chest to bear great blows with impunity. A blow on the sternum is distributed over fourteen elastic arches! One can understand, then, why the chest is able to bear such tremendous blows with impunity; more especially during a full inspiration. During expiration the bones are less able to resist injury, because the muscles are not acting. Notwithstanding these beautiful provisions, the sternum is sometimes broken, especially when the cartilages of the ribs are ossified. Dupuytren mentions the case of a fireman whose sternum was broken by the fall of a piece of timber. The man was carried away, supposed to be dead. Coming up accidentally, Dupuytren replaced the sternum, and the man recovered.

THORAX AS A
WHOLE.

In addition to what has been said of the thorax at p. 228, attention should be directed to one or two points which might otherwise be overlooked. 1. Notice the great narrowness of the upper opening of the chest. In an adult of average size, it measures about 2 inches from before backwards, and $3\frac{1}{2}$ inches transversely. Yet in this seemingly narrow space there is room for the trachæa, the œsophagus, the great bloodvessels and nerves at the root of the neck, besides the apex of the lung, and three muscles on each side. 2. Notice how much the ribs slope in subserviency to the mechanism of respiration. Their sternal and vertebral ends are not in the same horizontal plane; for instance, the sternal end of the third rib is not on a level with the third dorsal vertebra, but, roughly speaking, with the sixth. 3. Notice how much additional space is gained posteriorly (for the lungs) by the backward projection of the ribs. 4. Notice that

the lower margin of the thorax is represented by a line sloping from the end of the sternum downwards and backwards to the last rib. 5. Notice that the intercostal spaces are widest where the ribs unite to their cartilages; and narrowest where the ribs join the spine.

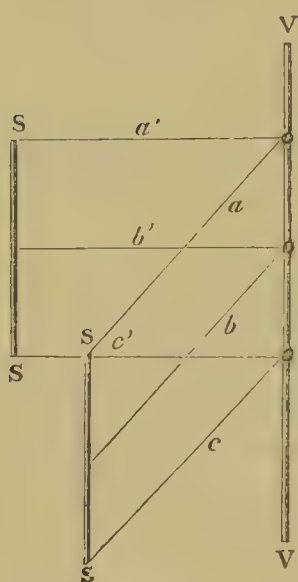
MECHANISM BY
WHICH THE THO-
RAX IS ENLARGED
IN INSPIRATION.

It is proposed to explain at present how the chest is enlarged in the transverse and in the antero-posterior direction by the elevation of the ribs.

The spine is fixed, and serves as a fulcrum for the ribs, which are the levers.

At the moment of inspiration, the ribs, which you must remember are oblique, are raised by the intercostal muscles. The centre of motion being at the spine, it is plain that the more nearly the ribs become horizontal, the greater will be the distance between the spine and the sternum.

FIG. 74.



Thus, let the line V V, in fig. 74, represent the spine; the line S S the sternum; a, b, c , three ribs in their oblique position; and a', b', c' , the same ribs elevated. It is obvious that by raising the ribs we increase at the same time the antero-posterior diameter of the chest; or, in other words, we increase the distance between the spine V V and the sternum S S.

The same diagram proves that, when the ribs are raised, the intercostal spaces are widened; that is, a perpendicular let fall between two ribs is longer when the ribs are raised than when they are depressed.

Now, when the ribs rise, they describe a rotatory movement

FIG. 75.



around an imaginary axis, as shown at A B, fig. 75, which unites their vertebral and sternal ends. In consequence of this rotation on its ends, the external surface of the rib, which looks downwards and out-

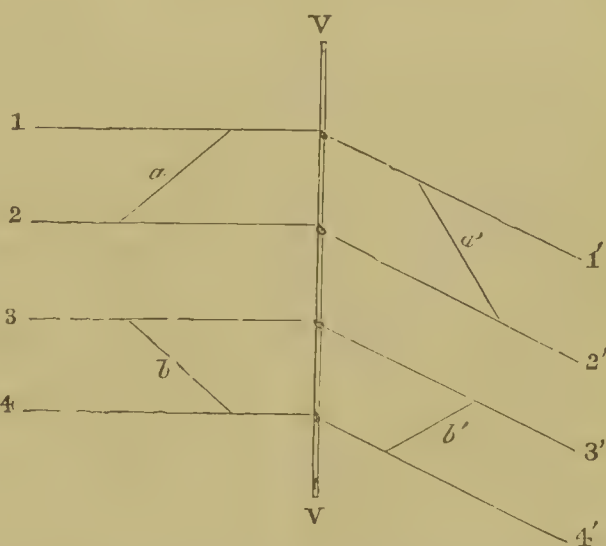
wards when at rest, looks directly outwards when raised. Thus the *transverse* diameter of the chest is increased.

If the ribs were all of the same length, as in fig. 74, the projection of the sternum, caused by their elevation, would be equal all the way down. But since the lower sternal ribs are longer than the upper, it follows that the sternum is projected in inspiration more and more towards its lower end.

Next come the questions, how are the ribs raised, and how are they depressed? They are *raised* by the external intercostal muscles (which run obliquely downwards and forwards); they are *depressed* by the internal intercostal muscles (which run obliquely upwards and forwards). These facts are rendered probable (if not absolutely proved) by the following diagram:—

Let V V represent the spine, 1' 2' two ribs in a state of obliquity or rest, and α' a fibre of an external intercostal muscle. Now, when the fibre α' contracts, it shortens itself: but this shortening cannot take place unless the ribs are at the same time brought more into the horizontal line, as shown at 1, 2;

FIG. 76.



in other words, unless they are raised; therefore the external intercostal muscles are *inspiratory* muscles.

The same kind of demonstration proves that the internal intercostal muscles depress the ribs, and are therefore *expiratory* muscles. For let b be a fibre of an internal intercostal muscle extended between the ribs 3 and 4 in a state of elevation, it is easy to see that, when the fibre b contracts or shortens itself, it cannot do so without bringing the ribs into a more oblique position, as shown at 3' and 4'. That the fibre b' must be shorter than the fibre b may be proved by a pair of compasses.

MUSCLES OF THE BACK.

(PLATES L. TO LV.)

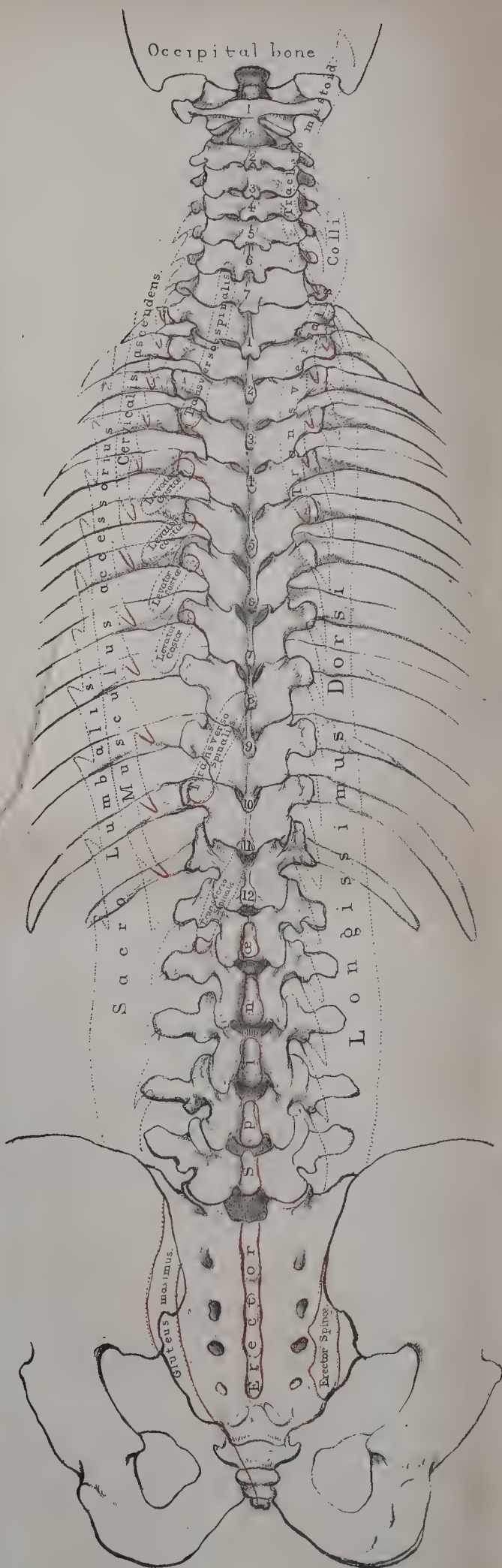
IN the description of the muscles of the back we propose to take, first, the more superficial muscles connected with the arm. These removed, we bring into view the great muscles of the spine, which fill up the vertebral grooves, and keep the body erect. Lastly, we have the mass of muscles at the back of the neck which are attached to the occipital bone.

THE SUPERFICIAL MUSCLES OF THE BACK.

These are shown in Plate L. The most superficial is the ‘trapezius,’ a triangular muscle of which the limits are defined by the continuous dark line. The other wide-spreading superficial muscle is the ‘latissimus dorsi.’ Under the trapezius we have the ‘rhomboideus’ and the ‘levator anguli scapulæ’ shown in Plate LII.

Trapezius.....	{	O. Occiput; ligamentum nuchæ: spines of all the dorsal vertebræ.
	{	I. Spine of scapula; acromion, acromial third of clavicle.
Latissimus dorsi.....	{	O. Crest of the ilium. Spines of all the lumbar, and six lower dorsal vertebræ, and by digitations from the three lower ribs.
	{	I. Bottom of bicipital groove of humerus.
Rhomboideus (major and minor)	{	O. Spines of last cervical and five upper dorsal vertebræ.
	{	I. Posterior border of scapula.
Levator anguli scapulæ.....	{	O. Transverse processes (posterior tubercles) of four upper cervical vertebræ.
	{	I. Upper angle of scapula.

When the preceding muscles are removed, we have still to take off the ‘serratus posticus superior’ and ‘inferior.’ Understand, these belong neither to the arm nor the spine, but to the ribs.





- Serratus posticus superior..... { O. Spines of last cervical and three upper dorsal vertebrae.
 { I. Second, third, and fourth ribs.
- Serratus posticus inferior..... { O. Spines of two last dorsal and two upper lumbar vertebrae.
 { I. Four lower ribs.

We come now to the great muscles of the spine concerned in keeping the body erect. These are considered to be complicated: the truth is, they are very simple, provided the plan of their arrangement be borne in mind. An attempt has been made to bring out the plan in Plate LI.

The vertebral groove on each side of the spine is occupied by the 'erector-spinae' and its prolongations, and also by the 'transverso-spinalis.'

The 'erector-spinae' arises by strong tendons from the crest of the ilium, back of the sacrum, and the spines of the lumbar vertebrae; and subdivides into two masses of muscle. The outer, termed the 'sacro-lumbalis,' with its prolongations (musculus accessorius and cervicalis ascendens), is attached to the *angles* of the ribs. The inner, termed the longissimus dorsi, with its prolongations (transversalis colli and trachelo-mastoid), is attached to the *transverse processes* of the vertebrae. Subjoined, these muscles are arranged in a natural tabular form. They all run longitudinally.

PLAN OF THE LEFT ERECTOR SPINÆ.

Angles of ribs.		
	Sacro-lumbalis.	2, 3, 4, 5, 6 ribs.
	I. 6 lower ribs.	O. Musculus accessorius.
		I. 6 upper ribs.
		O. Cervicalis ascendens.
		I. 4 lower cervical vertebrae.
O. ERECTOR-SPINÆ		
	outer mass.....	
	inner mass.....	
Transverse processes of vertebrae.	Longissimus dorsi.....	Transversalis colli.....
	I. all the lumbar and dorsal vertebrae.	O. 5 or 6 upper dorsal vertebrae.
		I. Mastoid process.

Crest of ilium.
 Back of sacrum.
 Spines of lumbar vertebrae.

Feb 1. 1874

The 'intertransversales' pass between the transverse processes of contiguous vertebræ, the 'interspinales' between the spinous processes beginning at the axis. Both these sets are ill developed and mostly tendinous in the dorsal region.

The 'transverso-spinalis' is the mass which fills up the space between the transverse and spinous processes of the vertebræ. It arises from transverse, and is inserted into spinous processes. Therefore its direction is oblique. It is composed of several bundles. The more superficial pass over many vertebræ; the deeper, over one or two; the deepest run from vertebra to vertebra. The 'transverso-spinalis' comprises the 'semi-spinalis-dorsi,' 'semi-spinalis colli,' 'multifidus spinæ,' and 'rotatores spinæ' of systematic authors.

The 'levator costarum' arise from the transverse processes, and are inserted into the ribs below them.

MUSCLES OF THE BACK OF THE NECK.

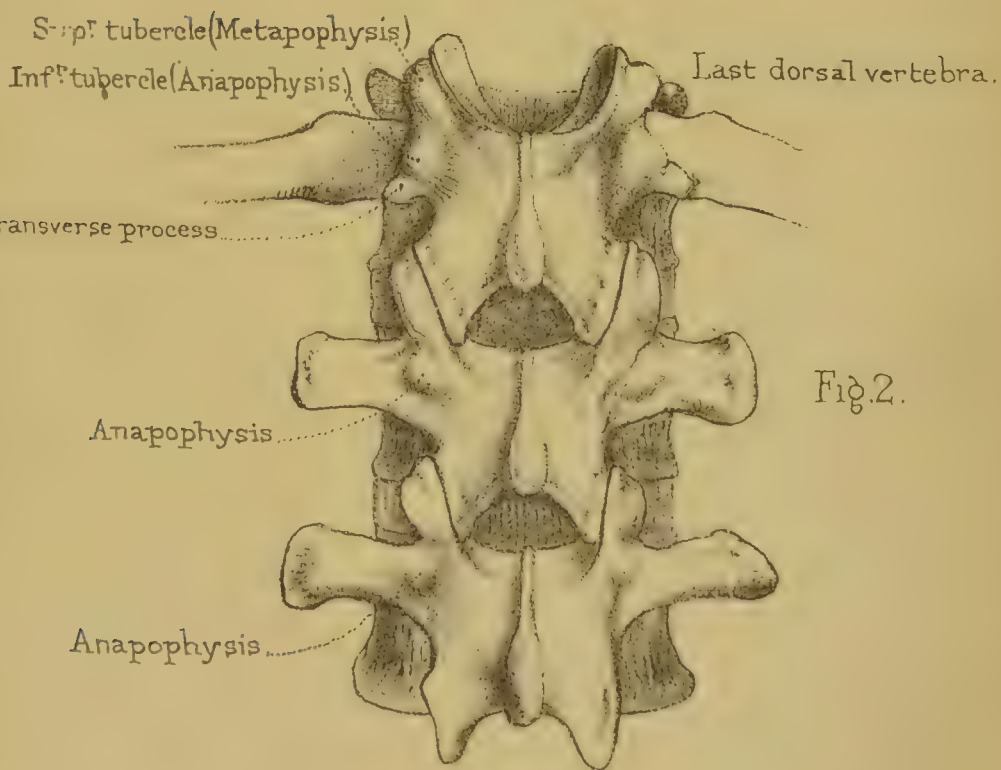
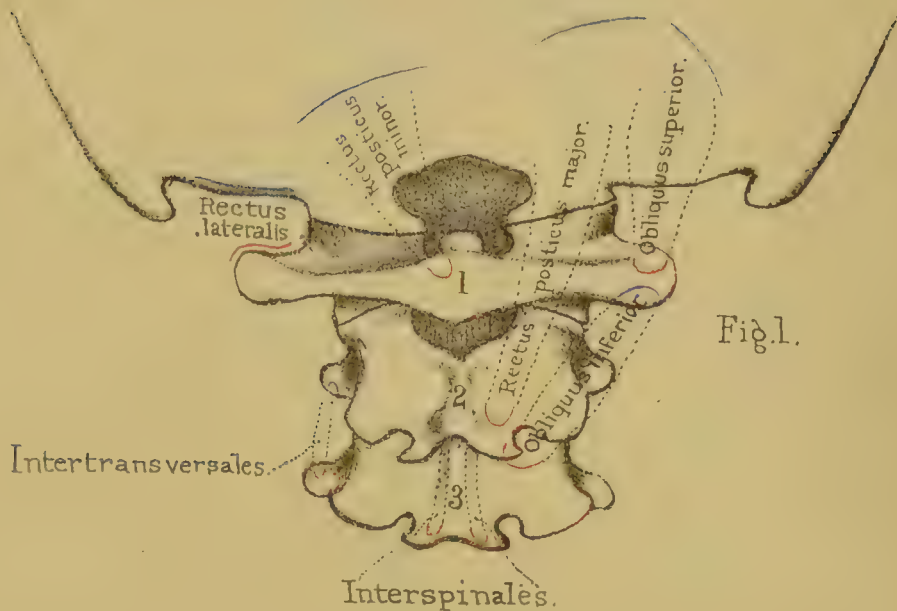
(PLATE LIII.)

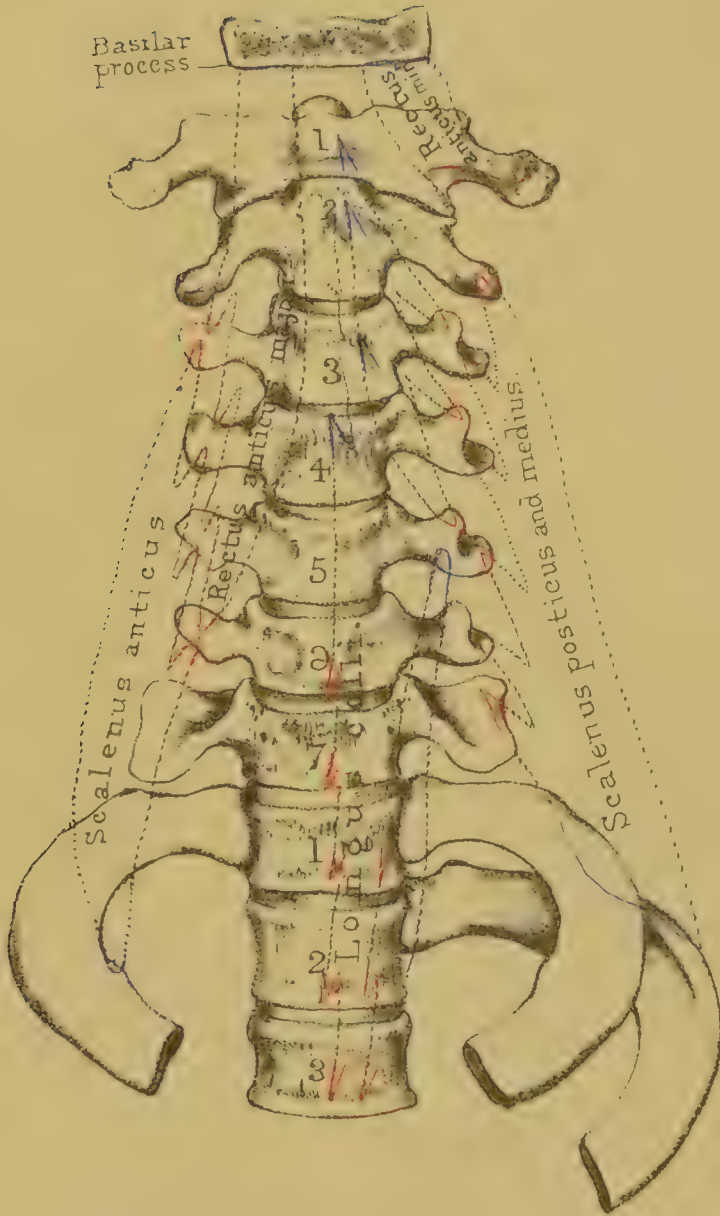
A separate group is made of these, because they are specially intended to maintain the head erect, and to move the first upon the second vertebra. The 'trapezius' being reflected, we come upon the 'splenius,' and beneath that upon the 'complexus.'

Splenius capitis et colli.....	{	O. Spines of four cervical and six dorsal vertebræ.
	{	I. Mastoid process and occipital bone; transverse processes of three upper cervical vertebræ.
Complexus	{	O. Transverse processes of six dorsal and articular processes of four cervical vertebræ.
	{	I. Occipital bone.

The above muscles being reflected, we expose the muscles of the atlas and axis; namely, the 'rectus capitis posticus major' and 'minor,' 'the obliquus superior' and 'inferior' and the 'rectus lateralis.'

Occipital bone.





Drawn on Stone by T. Godart
From nature by L. Holden

Printed by W. West & Co.

Rectus capitis posticus major..	{ O. Spine of the axis. I. Occipital bone.
Rectus capitis posticus minor.	{ O. Spine of the atlas. I. Occipital bone.
Rectus capitis lateralis	{ O. Transverse process of atlas. I. Jugular eminence of occipital bone.
Obliquus superior	{ O. Transverse process of atlas. I. Occipital bone.
Obliquus inferior	{ O. Spine of the axis. I. Transverse process of atlas.

MUSCLES IN FRONT OF THE SPINE.

(PLATES LIV., LV.)

There are three pre-vertebral muscles in the cervical region; namely, the ‘rectus capitis anticus major’ and ‘minor,’ and the ‘longus colli.’ In the lumbar region we have the right and left crura of the ‘diaphragm,’ the ‘psoas magnus,’ and occasionally a ‘psoas parvus.’

Rectus capitis anticus major...	{ O. Transverse processes of third, fourth, fifth, and sixth cervical vertebræ. I. Basilar process.
Rectus capitis anticus minor...	{ O. Transverse process of atlas. I. Basilar process.

The ‘longus colli’ consists of a longitudinal and an oblique portion. The *longitudinal* part *arises* from the bodies of the three upper dorsal and two lower cervical vertebræ, and is inserted into the bodies of the second, third, and fourth cervical vertebræ. The *oblique* part *arises* from the transverse processes of the third, fourth, and fifth cervical vertebræ, and is *inserted* into the tubercle of the atlas. Other oblique fibres arise from the bodies of the three upper dorsal vertebræ, and are inserted into the transverse process of the fifth cervical vertebra.

Diaphragm	{ O. Right crus from four lumbar vertebræ, left from three. I. Central tendon.
Psoas magnus	{ O. Bodies and transverse processes of all the lumbar vertebræ. I. Trochanter minor.
Psoas parvus	{ O. Body of last dorsal vertebra. I. Brim of pelvis.

OS HYOIDES.

(PLATE LVI.)

POSITION AND
USE.

The os hyoides, so called from its likeness to the Greek letter Upsilon, is situated between the larynx and the root of the tongue. It is suspended from the styloid processes of the temporal bones by the stylo-hyoid ligaments, often partly ossified in man, and, generally, distinct bones in animals. When the neck is in its natural position, it can be plainly felt on a level with the lower jaw, and about one inch and a half behind it. It serves to keep open the top of the larynx, and affords attachment to the muscles which move the tongue.

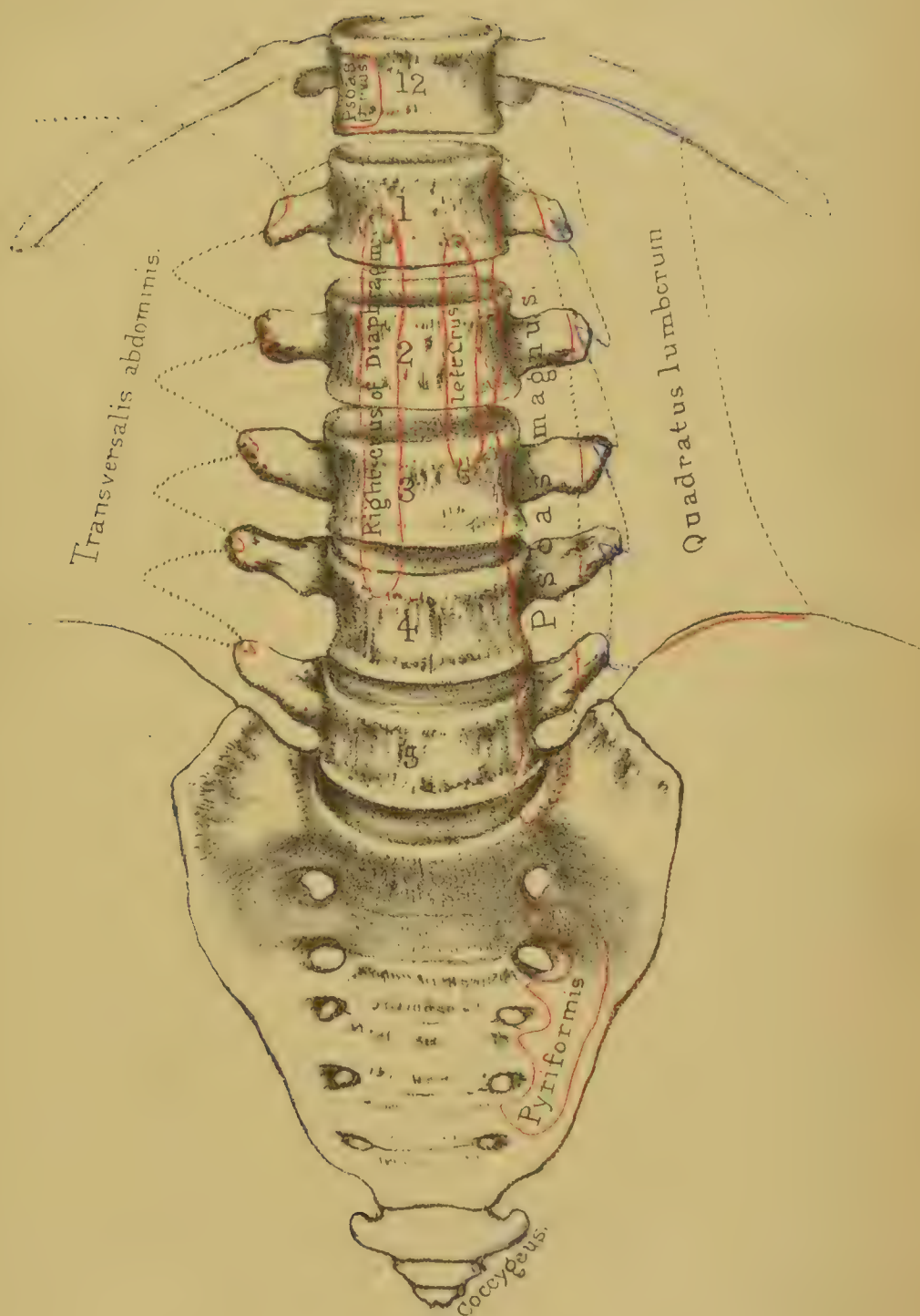
It is divided, for the sake of description, into a 'body' or front part, and a 'greater' and a 'lesser cornu' on each side.

BODY.

The 'body' (basi-hyal part), is the thickest and strongest part. Its *upper* surface is marked by the impressions of the muscles attached to it. There is, generally, a transverse and a perpendicular ridge: the latter is in the median line. Often there is a little projection from the middle, which is interesting as a rudiment of the process to which is attached the lingual bone of animals, which runs into the substance of the tongue. Its *under* surface is slightly excavated, as seen in fig. 2, which shows a transverse section through the centre of the body. Observe, this hollow is not for the attachment of muscles, but for the purpose of making room for the thyroid cartilage to rise behind the os hyoides in deglutition. It is a rudiment of the great cavity which forms the drum in the hyoid bone of the howling monkeys (*Myctes*). Observe, moreover, that the plane of the body is nearly horizontal, and that the thyro-hyoid ligament is attached to its *posterior* border.

CORNUA.

The *greater* cornu ('thyro-hyal' part) projects backwards about one inch and a half, not quite horizontally, but with a slight inclination upwards, and terminates in a blunt end, tipped with cartilage. Until the



middle period of life, the great cornu is united to the body by cartilage; but this ossifies in the progress of age.

The *lesser* cornu ('cerato-hyal' part) is not much larger than a barleycorn, and projects backwards at an acute angle from the junction of the body and the greater cornu. It articulates with the body by a little joint, and is freely movable: the stylo-hyoid ligament is attached to the end of it.

The many muscles attached to the hyoid bone are shown in the plate.

The os hyoides is connected to the thyroid cartilage by three ligaments, which contain a large quantity of elastic tissue. These ligaments are:—1. The *anterior thyro-hyoid* (Plate LVII. fig. 1), which proceeds from the 'pomum Adami' to the upper part of the body of the os hyoides. 2. The two *posterior thyro-hyoid*, which extend, one on each side, from the end of the great cornu of the os hyoides to the superior cornu of the thyroid cartilage. The vacant space left in the dried preparation between the hyoid bone and the thyroid cartilage is closed in the recent state by the *thyro-hyoid membrane*.

OSSIFICATION.

The bone is ossified from five centres—one for the body, and one for each of its four cornua.

GENERAL SURVEY OF THE SKELETON.

A GENERAL survey of the human skeleton, shows how admirably it is adapted to the erect attitude.

ADAPTATION OF
THE SKELETON TO
THE ERECT POSI-
TION.

1. When a man stands erect, an imaginary vertical plane (*ab*) supposed to fall through the top of the head, would pass through the occipito-atlantoid, lumbo-sacral, sacro-iliac, hip, knee, and ankle-joints; in a word, through all the joints which transmit the weight to the ground. This explains why a man can carry a weight on the top of his head easier than in any other way.

FIG. 77.



POSITION OF Fo-
RAMEN MAGNUM
AND CONDYLES.

2. The foramen magnum and the condyles of the occiput are nearly horizontal (when the head is held upright), and they are advanced almost to the middle of the base of the skull, so that the head may be nicely balanced on the cups of the atlas. True, there is a slight tendency in the head to drop forward, but this is compensated by the great strength of the muscles which keep the head erect. Contrast the position of the condyles in the human skull with that of the ourang-utan, in which the condyles are not only placed nearer to the *back* of the head, but obliquely, so as to make an angle of 40° with the horizon. The lower we go in the scale, the greater is the contrast. In the horse, for instance, the plane of the condyles and foramen magnum is vertical. In this, and all

other herbivorous quadrupeds, the weight of the head is sustained, not by muscular power, but by an enormously strong and elastic ligament (ligamentum nuchæ, or *back-war*), which

extends from the lofty spines (withers) of the dorsal vertebrae to the crest of the occiput.

DIRECTION OF
THE FACE.

3. The face is placed perpendicularly under the cranium, so that the plane of the face and forehead correspond, and this characteristic of the 'human face divine' is the form best adapted for the erect attitude. If man went on all fours, he would habitually see and smell nothing but the ground. As it is, the direction of the orbits is horizontal, and therefore gives the greatest range of vision; and the direction of the nose gives the greatest range of smell. We are all reminded here of the beautiful lines—

'Pronaque dum spectent animalia cætera terram,
Os homini sublime dedit, cælumque tueri
Jussit, et erectos ad sidera tollere vultus.'

OVID, *Metam.* I. 84-86.

BREADTH OF
THE THORAX.

4. The thorax is much broader in the transverse than in the antero-posterior diameter, which is peculiar to man and the highest species of ape. This great breadth of the chest throws the arms farther apart, and gives them a more extensive range; besides which, it diminishes the tendency there would otherwise be in the trunk to fall forwards. Contrast this with the chest of quadrupeds, compressed laterally, and deep from sternum to spine, that the fore legs may come nearer together, and fall perpendicularly under the trunk.

CURVES OF THE
SPINE.

5. The vertebral column gradually increases in size towards the base. It is curved, which makes it all the stronger, and better adapted to break and diffuse shocks: and these curves wave alternately, so as to distribute the weight advantageously with regard to the line of gravity. This line passes through all the curves, and falls exactly on the centre of the base. Observe, moreover, the length and size of the spinous processes in the lumbar region for the origin of the 'erector-spinae.'

SHAPE AND
INCLINATION OF
THE PELVIS.

6. The weight of the vertebral column is supported on a sacrum broader in proportion than in any other animal. The iliac bones are widely expanded and concave internally, to support the viscera and give

powerful leverage to the muscles which balance the trunk. The whole pelvis is remarkably broad, to widen the base of support; and the plane of its arch inclines so as to transmit the weight from the sacrum (or crown of the arch) vertically on to the heads of the thigh bones: lastly, the deepest and strongest part of the socket for the thigh bone is in the line of weight: consequently, the joint is never more secure than in the erect position.

With the broad and capacious pelvis of man, contrast the long and narrow pelvis of animals, which, instead of forming an angle with the spine, is almost in the same line with it.

LOWER LIMBS.

7. In proportion to the trunk, the lower limbs of man are longer than in any other mammal, the kangaroo not excepted. Their great length prevents their being adapted for locomotion in any but the erect attitude. The femur has a long neck, set on to the shaft at a very open angle, so that the base of support is rendered still wider. The long shaft of the femur inclines inwards, to bring the weight well under the pelvis, which is obviously of great advantage in progression: and when the leg is extended, the femur can be brought into the same line with the tibia: thus the weight is transmitted vertically on to the horizontal plane of the knee-joint, and the articular surfaces of the bones are expanded to give adequate extent of support.

Contrast our long lower limbs with the short and bowed legs of the gorilla, chimpanzee, and ourang-utan. Watch attentively one of these three apes (the highest of the mammalia below man) in the act of walking; you will find that he supports himself alternately on the right and left knuckles as well as on his feet.

FEET.

8. The foot of man is broader, stronger, and larger in proportion to the size of the body than in any other animal; so that man can stand on one leg, which no other mammal can do. Its strong component bones form a double arch of exceeding elasticity, which touches the ground at both ends, and receives the superincumbent weight vertically on its 'crown.' The great bulk and backward prolongation of the os calcis at right angles to the tibia support the arch behind, and form a powerful lever for the great muscles of the calf, which raise the body in progression, and the bones of the great toe are

proportionably strong, to form the chief support upon which the body may be raised.

UPPER LIMBS AND
HANDS.

9. We see, then, that the whole fabric of the skeleton is adjusted so as to exempt the upper limbs from taking any part in its support. These are kept wide apart by the clavicles, and their component joints admit of the freest range of motion. The twenty-seven bones at the extremity of each constitute those instruments of consummate perfection, the 'HANDS,' of which, even if a formal dissertation* had not been written, one might well forbear to speak, since they have such eloquence of their own. 'Nam cæteræ partes loquentem adjuvant, hæ, prope est ut dicam, ipsæ loquuntur: his poscimus, pollicemur, vocamus, dimittimus, minamur, supplicamus, abominamur, timeamus; gaudium, tristitiam, dubitationem, confessionem, pœnitentiam, modum, copiam, numerum, tempus, ostendimus.' †

* See Bell's Bridgewater Treatise, 'The Hand.'

† Quintilian.

*Sanctius plus animal mentisque capacius est
Deus autem ad hoc, ut per se
Hominem est Homo.*

THE LARYNX.

(PLATE LVII.)

SITUATION AND USE. THE LARYNX is situated at the top of the trachæa or windpipe. It answers a double purpose. It guards the opening through which the air passes into the lungs: it is the organ of the voice and of song. Its framework, which we now propose to examine, consists of a number of cartilages connected by joints and elastic ligaments in such a way that they can be moved upon each other by appropriate muscles; the object of this motion being to act upon two elastic ligaments termed the 'vocal cords,' upon which the voice essentially depends.

NUMBER AND NAMES OF THE CARTILAGES. The chief cartilages are named, respectively, the thyroid, the cricoid, the two arytenoid, and the epiglottis. Besides these, there are four very little and much less important cartilages, namely, the two 'cornicula' and the two 'cuneiform' cartilages. In all, then, there are nine.

Of these nine, four, namely, the thyroid, cricoid, and two arytenoid, are composed of hyaline cartilage, and are prone to ossify in old age. The remaining five are made up of yellow elastic fibro-cartilage, and have little tendency to ossify.

THYROID CARTILAGE. The thyroid cartilage is so named because it shields the fine apparatus behind it.* It consists of two lateral symmetrical plates (alæ), united in front at an angle which forms the prominence termed 'pomum Adami.' This prominence, which is greater in the male than in the female, has a 'notch,' at the upper part, as if a portion of the angle had been sliced off: the object of this is to permit the cartilage to rise with greater facility behind the os hyoides in deglutition. The body

* *Θυρεός*, a shield.

Os-hyoides:

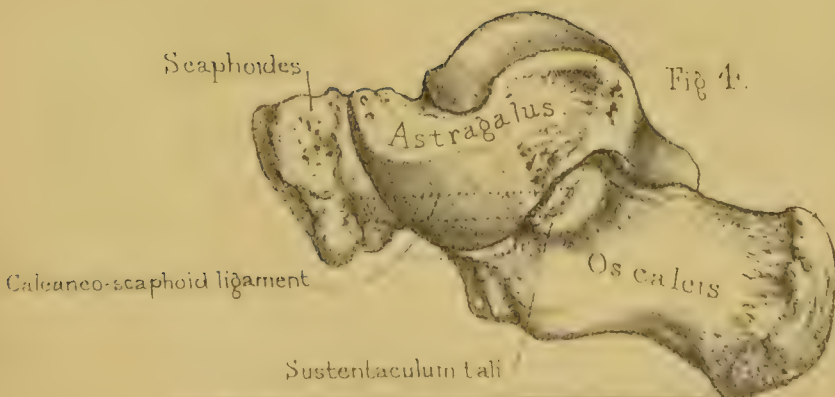
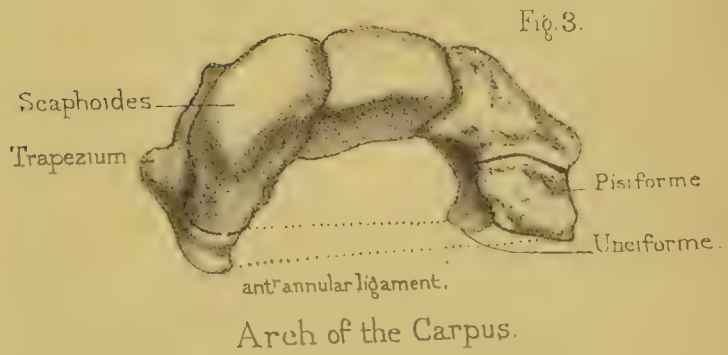
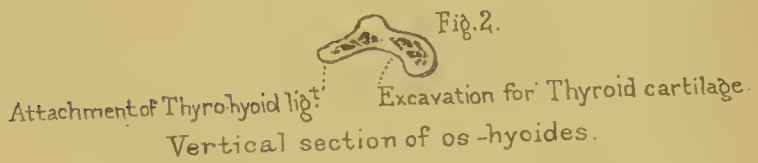
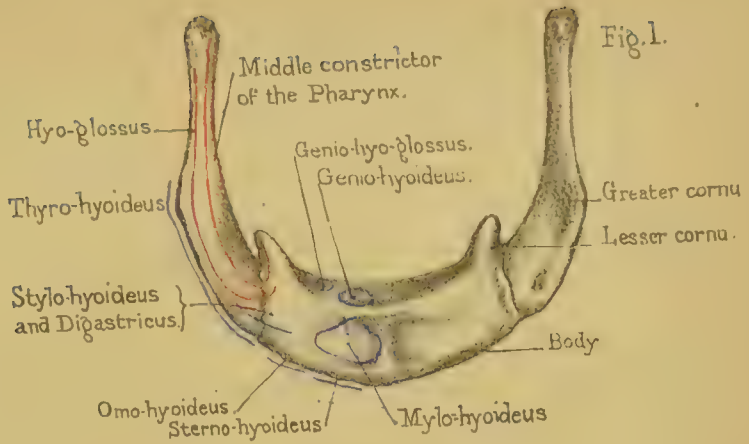


Fig. 1.

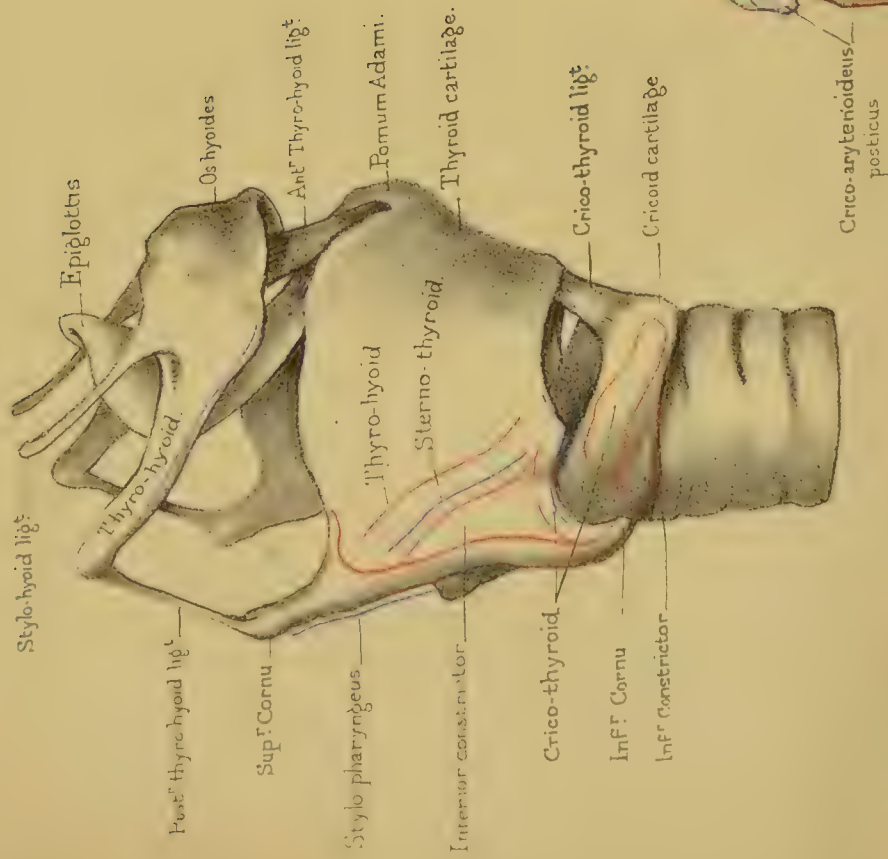


Fig. 5.

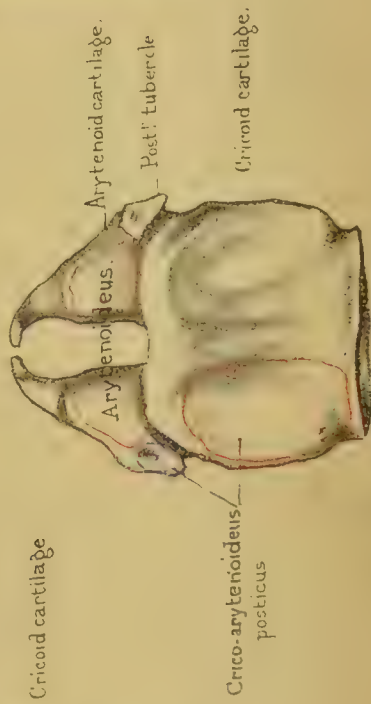
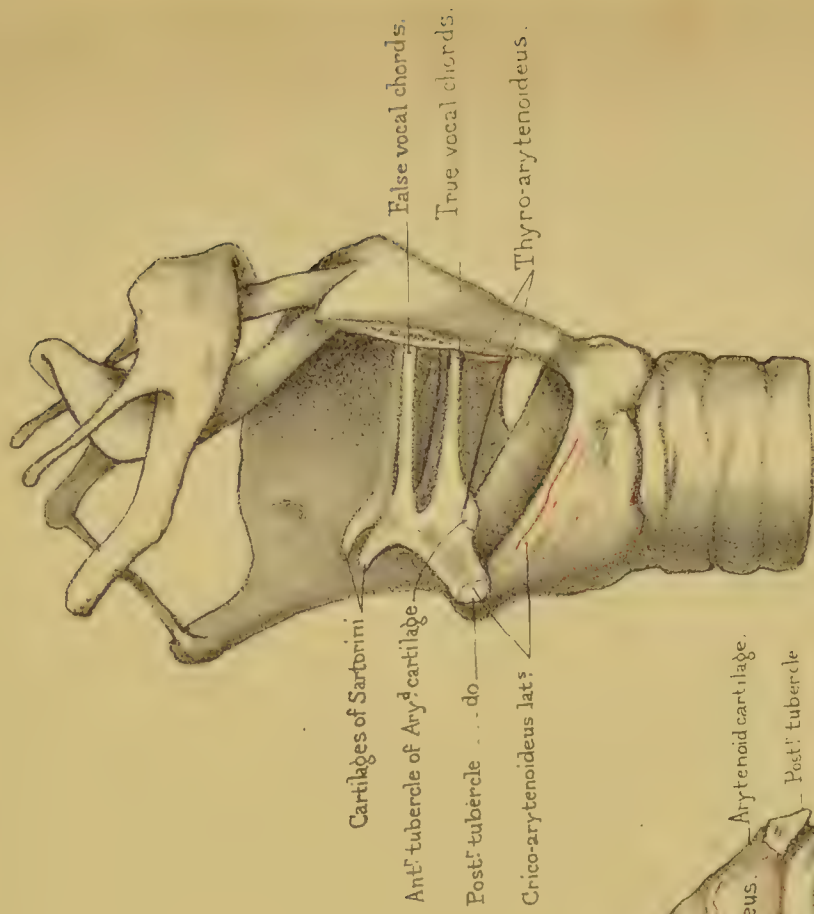


Fig. 2.



Post: surface of Cricoid and Arytenoid cartilages:

Drawn on Stone by 'L. Godart.

of the os hyoides is excavated for this express purpose (p. 242). More than this, there is a bursa of considerable size to prevent friction between the surfaces. The bursa is practically interesting, because it may enlarge and form a cyst in front of the neck. I have seen it as large as a pigeon's egg.

OUTER SURFACE AND RIDGE. Look at the outer surface of the ala of the thyroid cartilage (fig. 1). Observe that it has an oblique ridge, running downwards and forwards, with tubercles at each end, indicative of the attachments of muscles. The ridge gives origin to the thyro-hyoid and insertion to the sterno-thyroid muscles. Behind the ridge is the origin of the inferior constrictor of the pharynx, which we trace down to the side of the cricoid cartilage. The *posterior* border of the ala is nearly vertical, and gives insertion to the stylo-pharyngeus. The *inferior* border of the ala has generally two curves, and gives insertion to the 'crico-thyroid' muscle. This muscle, observe, arises from the side of the cricoid cartilage; consequently, when it acts, it draws the two cartilages together.

CORNUA. The posterior part of each ala has two projections, termed its 'cornua' superior and inferior. The superior cornu gives attachment to the posterior thyro-hyoid ligament. The inferior cornu articulates with the cricoid cartilage. This is a perfect joint, provided with a synovial membrane and ligaments. It is important to remember that the form of the joint admits of only vertical movement of the thyroid cartilage, the axis of motion being a transverse line drawn through both joints. We shall presently see that upon this movement depends the tuning of the vocal cords.

ANGLE. PARTS CONNECTED TO IT. So much for the outside of the thyroid cartilage. Now for the parts attached within the angle. To see them properly, one of the alæ should be removed, as in fig. 2. You then observe that the following objects are attached to the angle beginning at the top: 1, the anterior thyro-hyoid ligament; 2, below this, the apex of the epiglottis; 3, lower down, the false vocal cords; 4, still lower, the true vocal cords; 5, below these, the origin of the 'thyro-arytenoideus'; lastly, at the lower border of the angle, is the attachment of the 'crico-thyroid' ligament.

CRICOID
CARTILAGE.

The cricoid cartilage (Plate LVII.) forms a complete ring (whence its name), a little broader in the antero-posterior diameter than in the transverse. It is situated at the top of the trachæa, immediately below the thyroid cartilage. The ring is not of the same depth all round. Observe that it is narrow in front, and that from this part the upper border of the ring gradually rises, so that, behind, the ring is a full inch in vertical depth, and occupies part of the interval between the *alæ* of the thyroid. This slope of the cricoid towards the front is to permit the vertical play of the thyroid. The interval between the two cartilages can be plainly felt in the middle line of the neck; and in the adult it is about half an inch in depth. It is occupied by the crico-thyroid ligament, which connects the two cartilages. All that concerns this interval is practically interesting, because it is here that we perform laryngotomy. This operation consists in dividing the crico-thyroid ligament transversely close to the cricoid cartilage, that the incision may be as distant as possible from the vocal cords.

Passing from the front towards the side of the cricoid cartilage, notice the origin of three muscles, namely—the ‘crico-arytenoideus lateralis’ along the upper edge (fig. 2); the ‘crico-thyroid’ in the middle (fig. 1); and, lower down, a portion of the ‘inferior constrictor of the pharynx.’

At the back part of the cricoid cartilage (fig. 3) there is on either side a broad excavation for the origin of the ‘crico-arytenoideus posticus.’ Generally these muscles are separated by a slight vertical crest. At the top of the cricoid are the two small oval articular surfaces, one on each side, for the arytenoid cartilages, which we shall examine presently.

The side of the cricoid articulates with the inferior cornu of the thyroid cartilage by means of a perfect joint, provided with a synovial membrane and ligaments. The structure of this joint permits the two cartilages to move upon each other, so that their opposite borders can be approximated by the ‘crico-thyroid’ muscle. It deserves especial attention, because the degree of this approximation regulates the tension of the vocal cords.

Lastly, the lower border of the cricoid is horizontal, and connected to the first ring of the trachæa by an elastic membrane.

**ARYTENOID
CARTILAGES AND
CORNICULA
LARYNGIS.** The arytenoid cartilages, so named from their resemblance to an ancient ewer (*ἀρύταινα*), are situated, one on each side, at the upper part of the cricoid (fig. 3). Each is somewhat pyramidal in form, with the apex above, looking towards its fellow, and slightly curved backwards. The apex of each is surmounted by a nodule of cartilage, termed the ‘cartilage of Santorini’ (‘corniculum laryngis’). The base presents an oval concave surface, which forms a perfect joint, with a corresponding convex surface on the cricoid cartilage. This joint has a loose synovial membrane and ligaments, so that the arytenoid cartilages admit of being approximated or separated, a freedom of motion which is essential to the dilatation and contraction of the glottis or chink between the true vocal cords through which the air enters the trachæa.

**TUBERCLES OF
THE ARYTENOID.** At the base of each arytenoid cartilage (Plate LVII. fig. 2) observe the *anterior* tubercle to which the true vocal cord is attached, and the *posterior* tubercle, which gives insertion to two muscles, namely, the ‘crico-arytenoideus lateralis’ and the ‘crico-arytenoideus posticus’: more especially, notice that these muscles are inserted, not into the same side, but into *opposite* sides of the tubercle: the effect of which is that they antagonise each other.

Each arytenoid cartilage has three surfaces—a posterior, an anterior or external, and an internal. The posterior surface is excavated for the attachment of the ‘arytenoideus’ muscle (fig. 3), which crosses from one cartilage to the other, and fills up the gap between them. The anterior surface is also excavated, and occupied by the insertions of the ‘crico-arytenoideus lateralis’ and the ‘thyro-arytenoideus.’ The internal surface is flat, looks towards its fellow of the opposite side, and contributes to form part of the margin of the glottis.

EPIGLOTTIS. The epiglottis is a structure composed of yellow elastic cartilage situated at the base of the tongue, and projecting over the upper part of the larynx like the flap of a valve. In shape it somewhat resembles the leaf of an artichoke.

Its apex is attached to the angle of the thyroid cartilage. Its ordinary position is perpendicular, or nearly so, leaving the glottis free for respiration; but during deglutition the larynx is raised, and the tongue is depressed, so that the epiglottis becomes more horizontal, drops like a valve over the top of the larynx, and tends to prevent the entrance of food into it. This falling of the epiglottis is not produced by any special muscle; it is simply mechanical.

**CUNEIFORM
CARTILAGES.**

These cartilages are the smallest and least essential of the whole group. They are found in the 'aryteno-epiglottidean fold,' a prominent line of mucous membrane running on each side from the edge of the epiglottis to the apex of the arytenoid cartilage. They are thin and narrow, not much larger than pin's heads and not constant.

**VOCAL CORDS,
TRUE AND FALSE.**

The vocal cords are four elastic ligaments, two on each side, extending horizontally backwards from the angle of the thyroid cartilage to the anterior part of the arytenoid. The two lower, and the most important, are termed the 'true' vocal cords, because, by their vibration, they produce the voice: the two upper cords are called 'false,' because they have little or nothing to do with the voice. The rapidity and accuracy with which the true vocal cords can change their tension, their form, and the width of the slit between them, renders the voice the most perfect of musical instruments.

**ATTACHMENTS
OF VOCAL CORDS.**

The precise attachments of these cords are best seen in the dried larynx, in which all the surrounding soft parts have been removed, as shown in Plate LVII. fig. 2. Observe that the true vocal cords are attached in front close together to the angle of the thyroid cartilage, about a quarter of an inch from its lower edge, and that they diverge as they pass backwards to be attached to the anterior tubercle of the base of the arytenoid. The false cords also proceed from the angle of the thyroid a little higher than the true, to about the middle of the front part of the arytenoid. In the recent larynx these cords are not free all round, like the strings of a violin: they are only free along the sides which face each other; everywhere else

the true cords are in contact with muscle, and the false with fat and areolar tissue.

LENGTH OF VOCAL CORDS.

What is the length of the true vocal cords?

During life, their length is continually varying, to a slight degree, with the pitch of the voice; but, in the dead subject, they are about five-eighths of an inch in the adult male. In the several male larynges which I have before me, the cords differ more or less from each other in length, though not more than one-twelfth of an inch. These individual differences in the length of the cords make corresponding variations in the natural tone of the voice: e.g. tenor, barytone, or bass. A deep voice coincides with the longer cords; a shrill voice with the shorter. In the female the cords are about one-fourth shorter than in the male. In boys, too, they are much shorter than in the adult; hence the peculiar voice of boys. At puberty the cords lengthen with the development of the larynx, and the voice is said to break.

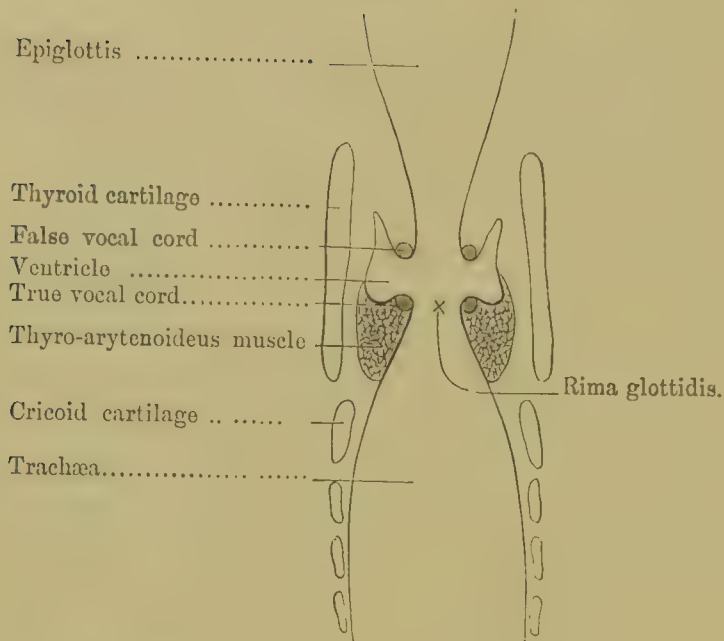
VENTRICLES OF THE LARYNX.

In the perfect larynx there is a little recess on each side between the true and the false vocal cords, like a little side pocket. These recesses are called 'the ventricles' of the larynx, and are best examined by cutting open the larynx. Their shape, depth and situation are represented in the outline on the next page, fig. 78, taken from a transverse perpendicular section of the larynx. Their use appears to be to allow free space for the vibration of the vocal cords, and probably to strengthen the voice. They are lined by the mucous membrane of the larynx, and the bottom of each is supported by the 'thyro-arytenoideus' muscle. The length of the ventricles from before backwards corresponds with the length of the vocal cords. Their greatest vertical depth is towards the front, which is the part represented in the section.

SIZE OF THE VENTRICLES.

The ventricles of the larynx are large enough to lodge a foreign body, such as a pea; and when an accident of this kind occurs, there is no rest for the patient until he dies, or the foreign substance is got rid of. A pill forced down a child's throat against its will has been known to catch in one of the ventricles, and occasion death, after a few struggles, from spasm of the glottis.

FIG. 78.

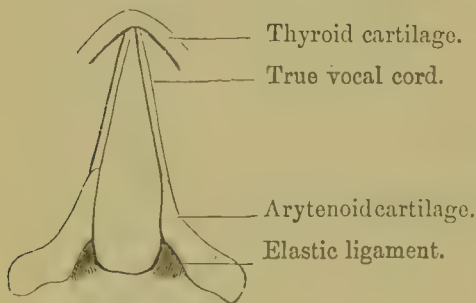


PERPENDICULAR SECTION, SHOWING THE VENTRICLES OF THE LARYNX.

RIMA GLOTTIDIS.

The term 'rima glottidis' or 'glottis' is applied to the interval or chink between the true vocal cords through which the air passes into and out of the trachæa. It

FIG. 79.

SHAPE OF THE GLOTTIS
WHEN AT REST.

is about one inch in length. Its boundaries (fig. 79) are formed by the vocal cords and by the arytenoid cartilages. The vocal cords form about the anterior two-thirds, the cartilages about the posterior third of the opening. The glottis admits of being made wider, or narrower, or may even be hermetically closed by

the action of muscles which we shall examine presently. In a state of rest it is triangular; the apex being in front at the thyroid cartilage, and the base between the arytenoid, as shown in fig. 79, where the arytenoid are cut through on a level with the vocal cords. When the glottis is dilated in *inspiration* by the

‘crico-arytenoidei postici,’ it becomes spear-shaped, as seen in fig. 81. During *expiration* the glottis gradually resumes its triangular shape or state of rest; and this return to state of repose is effected, not by muscle, observe, but by an elastic ligament shown in fig. 81, which draws the arytenoid cartilages towards the mesial line. We cannot but admire this beautiful provision. The glottis, like the chest, is dilated during inspiration by muscular tissue; like the chest, also, it is contracted during expiration by elastic tissue.

MUSCLES OF
THE LARYNX.

There are nine muscles to act specially upon the rima glottidis—four on each side, and one in the middle. The four on each side are the ‘crico-thyroidei,’ the ‘crico-

FIG. 80.

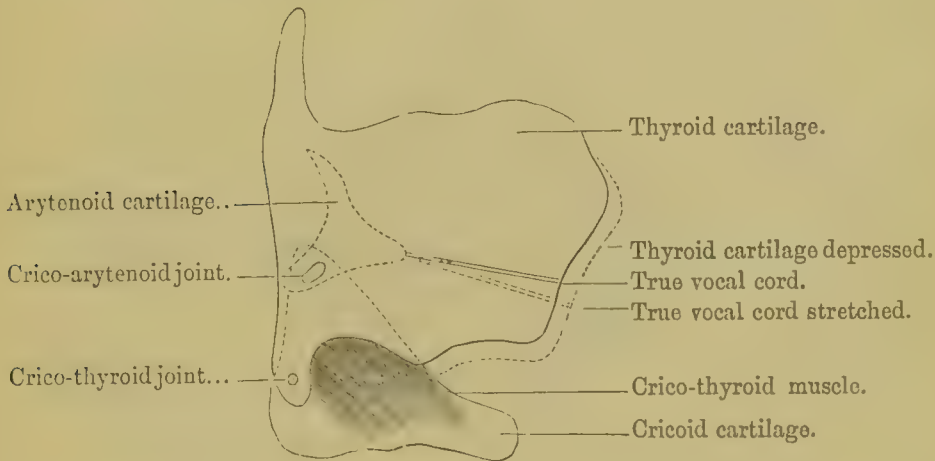


DIAGRAM SHOWING THE ACTION OF THE CRICO-THYROID MUSCLE.

arytenoidei postici,’ the ‘crico-arytenoidei laterales,’ and the ‘thyro-arytenoidei.’ The single one in the middle is the ‘arytenoideus.’ These we must now separately examine.

CRICO-THYROID
MUSCLES.

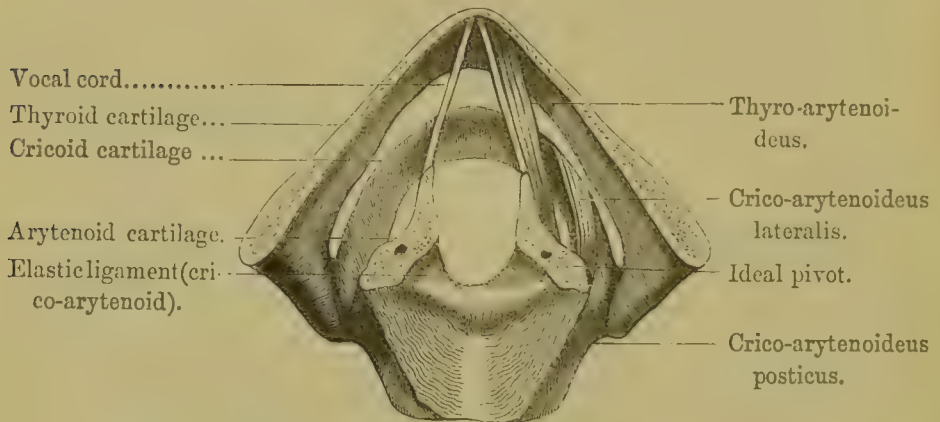
The ‘crico-thyroid’ is a short and strong muscle. It arises from the side of the cricoid cartilage, and is inserted into the lower border of the thyroid, including the lesser cornu. Its action is to stretch the vocal cords. It does this by depressing the thyroid cartilage, the arytenoid cartilage remaining fixed. Under this condition the thyroid cannot be depressed without increasing the distance between the attachments of the vocal cords, as shown by the dotted line in the cut, fig. 80.

Consequently the 'crico-thyroid,' when in action, must elongate the vocal cords.

CRICO-ARYTE-
NOIDEI POSTICI.

Each 'crico-arytenoideus posticus' arises from the posterior part of the cricoid cartilage, and is inserted into the posterior tubercle of the arytenoid. The muscle is seen in action (denoted by wavy lines) in fig. 81. Its action is to dilate the glottis. It does this by drawing the *posterior* tubercle of the arytenoid *towards* the mesial line, and therefore the *anterior* tubercle *from* the mesial line. In this movement the arytenoid cartilage rotates upon the cricoid as upon a pivot. Moreover, the arytenoid cartilage is a lever of the first order; the fulcrum or ideal pivot being intermediate between the power at the poste-

FIG. 81.



GLOTTIS DILATED. MUSCLES DILATING IT REPRESENTED WAVY.

rior tubercle and the weight or resistance at the anterior. The muscle in question is a most important one. It is a muscle of inspiration. It dilates the glottis every time we inspire. During expiration, when the glottis is restored to its state of rest, not by muscular action, but by an elastic ligament which we call the 'crico-arytenoid,' marked in fig. 81, the muscle relaxes, and has time to rest. This alternate contraction and relaxation of the 'crico-arytenoidei postici' is perpetually going on, from the first moment of life till the last.

CRICO-ARYTE-
NOIDEUS LATE-
RALIS.

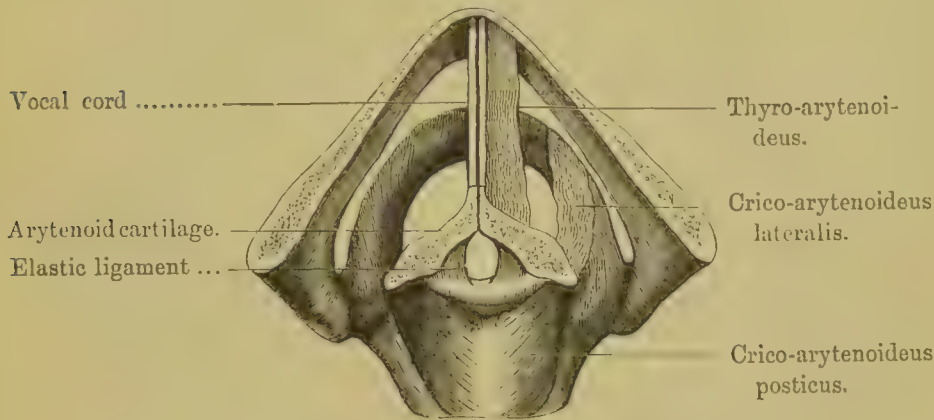
Each 'crico-arytenoideus lateralis' arises from the upper border of the cricoid cartilage, and is inserted into the posterior tubercle of the arytenoid.

Its action is to assist in closing the glottis, as seen in the cut, fig. 82. It does this by rotating the arytenoid cartilage in a way directly the reverse of the muscle last examined.

ARYTENOIDEUS. The 'arytenoideus' muscle arises from the back of one arytenoid cartilage, and is inserted into the back of the other. (Plate LVII. fig. 3.) Its action is to clasp the two cartilages together, and therefore to assist very materially in closing the glottis.*

THYRO-ARYTENOIDEI. Each of these muscles arises from the angle of the thyroid, and is inserted into the front surface of the base of the arytenoid. Their action is to relax the vocal

FIG. 82.



GLOTTIS CLOSED. MUSCLES CLOSING IT REPRESENTED WAVY.

cords, since they tend to draw together the cartilages to which they are attached. More than this, they assist in narrowing the glottis. But their special action appears to be that of bringing the lips of the glottis parallel to each other; that of placing them, in fact, in the 'vocalising' position. The glottis must be made not only a very narrow chink, but its lips must be brought parallel to each other, before they can be made to vibrate by the stream of the air, in such a manner as to produce voice or song. The motions of

* Certain muscular fibres in the aryteno-epiglottidean folds of mucous membrane assist the 'arytenoideus' and the 'crico-arytenoidei laterales' in closing the glottis. All these little muscles together form, as Henle has shown, a 'sphincter' of the glottis, a highly developed and complicated homologue of the single and simple sphincter muscle which embraces the entrance of the larynx in reptiles.

the glottis in singing, speaking, breathing, and coughing can be distinctly seen in the laryngoscope.

The following is a tabular arrangement of the action of the muscles of the larynx :

ANTAGONISTS	{ Crico-thyroidei.....stretch the vocal cords Thyro-arytenoidei.....relax the vocal cords }	govern the pitch of the notes.
ANTAGONISTS	{ Crico-arytenoidei postici.....open the glottis... Crico-arytenoidei laterales } Arytenoideus..... }	govern the opening of the glottis.

THE ANATOMY OF THE EAR.

IN describing the anatomy of this intricate and delicate organ, we propose to give first a general outline of its structure, and afterwards to go into the details of its several parts.

GENERAL IDEA OF THE SUBJECT. In order to give a general idea of the organ of hearing, we have made the diagram, fig. 1, Plate LVIII. Referring to this diagram, we recognise the elastic fibro-cartilage termed the ‘pinna’ of the ear, which collects the sonorous undulations of the air, and transmits them down the passage called the ‘meatus auditorius externus.’ This passage, about an inch and a quarter in length, is a little contracted in the middle and slightly curved with the concavity downwards. It is closed at the bottom by a fibrous membrane (*membrana tympani*) which is fixed in a groove in the bone, placed obliquely, and stretched in all respects like the parchment of a drum, except that its outer surface is a little concave. On the other side of this membrane is a

TYMPANUM. small chamber in the substance of the temporal bone, termed the ‘tympanum’ or middle ear. This chamber is filled with air, which is admitted through a tube (*Eustachian tube*) about an inch and a half long, leading from the back part of the nostrils into the front part of the tympanum. Thus there is an equilibrium of air on both sides of the *membrana tympani*. In fact, the *Eustachian tube* performs the same office for the ear as the hole which is made in the side of a drum for the necessary purpose of opening a communication with the external air. Opposite to the *Eustachian tube*, that is, at the back part of the tympanum, are the irregular openings of the mastoid cells which also contain air. All these air cavities are lined by a continuation of the same mucous membrane which lines the passages of the nose. This explains the degree of deafness which is often produced by a common cold, or other disease of the throat; the *Eustachian tube*

being temporarily obstructed by the swelling of its lining membrane.

OSSICULA
AUDITUS. MAL-
LEUS, INCUS, AND
STAPES.

In the tympanum itself we find three little bones (ossicula auditus) known separately by names more descriptive of their shape than their office—‘malleus,’ ‘incus,’ and ‘stapes.’ These bones are connected by perfect joints, so as to form a continuous chain, surrounded by atmospheric air, across the cavity of the tympanum; and the mucous membrane is reflected over them. The handle (manubrium) of the malleus at one end of the chain is attached to the ‘membrana tympani,’ and the foot-plate of the stapes at the other end closes the ‘fenestra ovalis,’ an opening on the inner wall of the tympanum leading to the ‘vestibule’ of the inner ear. Both ends of the bony chain, observe, are attached to membrane, since the foot-plate of the stapes does not exactly fit into the fenestra ovalis; membrane intervening between their edges. Moreover, certain little muscles, presently to be described, are attached to the bones, in order to slacken or tighten the membranes. Besides the fenestra ovalis, there is another opening in the inner wall of the tympanum, called the ‘fenestra rotunda.’ It leads into the cochlea and is closed by membrane.

INTERNAL EAR.

The internal ear, often called, on account of its intricacy, the ‘labyrinth,’ consists of a little chamber termed the ‘vestibule,’ the three ‘semicircular canals,’ and the ‘cochlea.’ All these parts are imbedded in the petrous portion of the temporal bone, like passages cut out of a solid rock. Hence the great difficulty of exploring them. Bear in mind their

VESTIBULE.

relative position. The ‘vestibule’ is in the middle, the canals are behind and the cochlea is in front. The vestibule communicates, behind, with the five openings of the semicircular canals; in front, with the cochlea; on the outer side with the tympanum through the fenestra ovalis (occupied by the stapes); and on the inner side by minute apertures with the meatus auditorius internus through which the auditory nerve enters the ear. These apertures transmit those branches of the auditory nerve which supply the membranous contents of the vestibule and the semicircular canals.

Fig. 1.

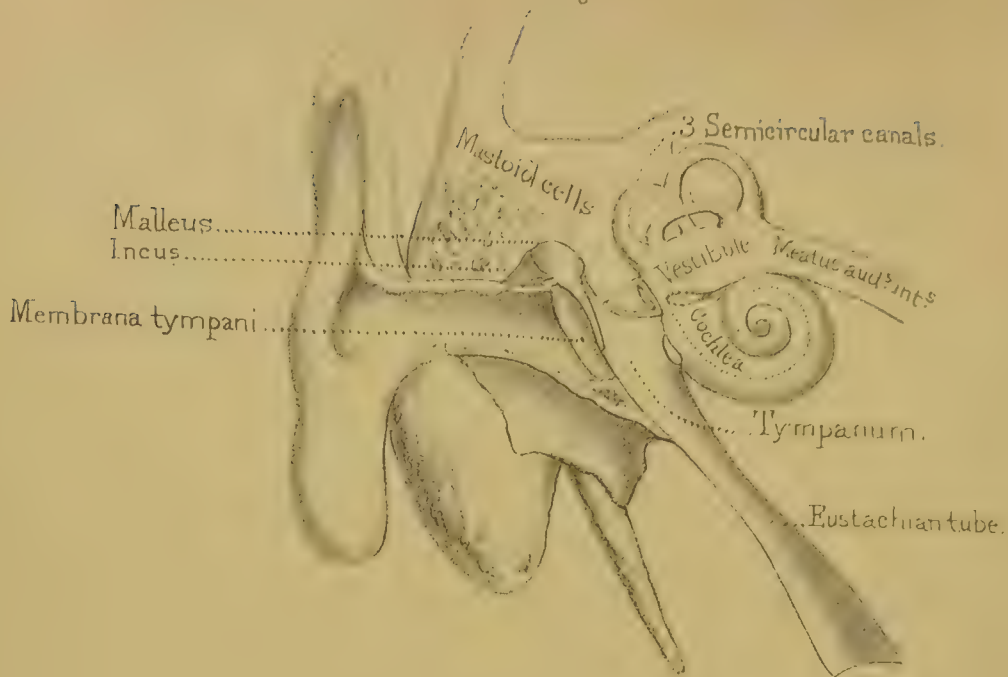
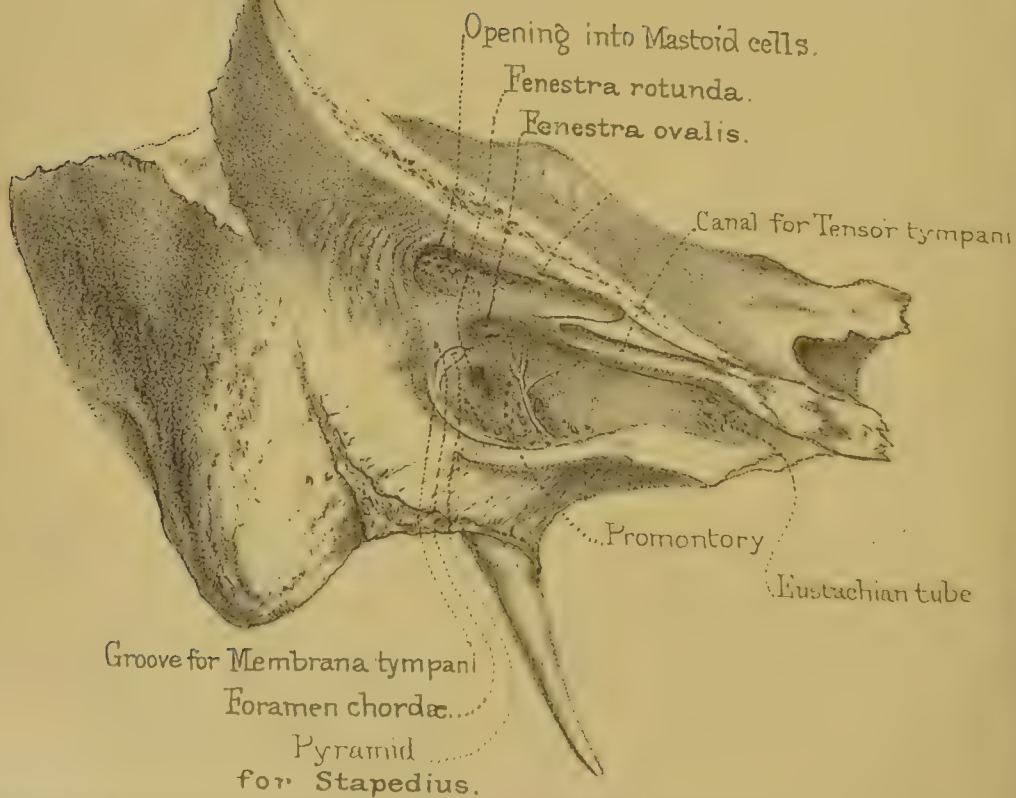


Diagram of the Ear.

Fig. 2.



Preparation to shew inner wall of tympanum.

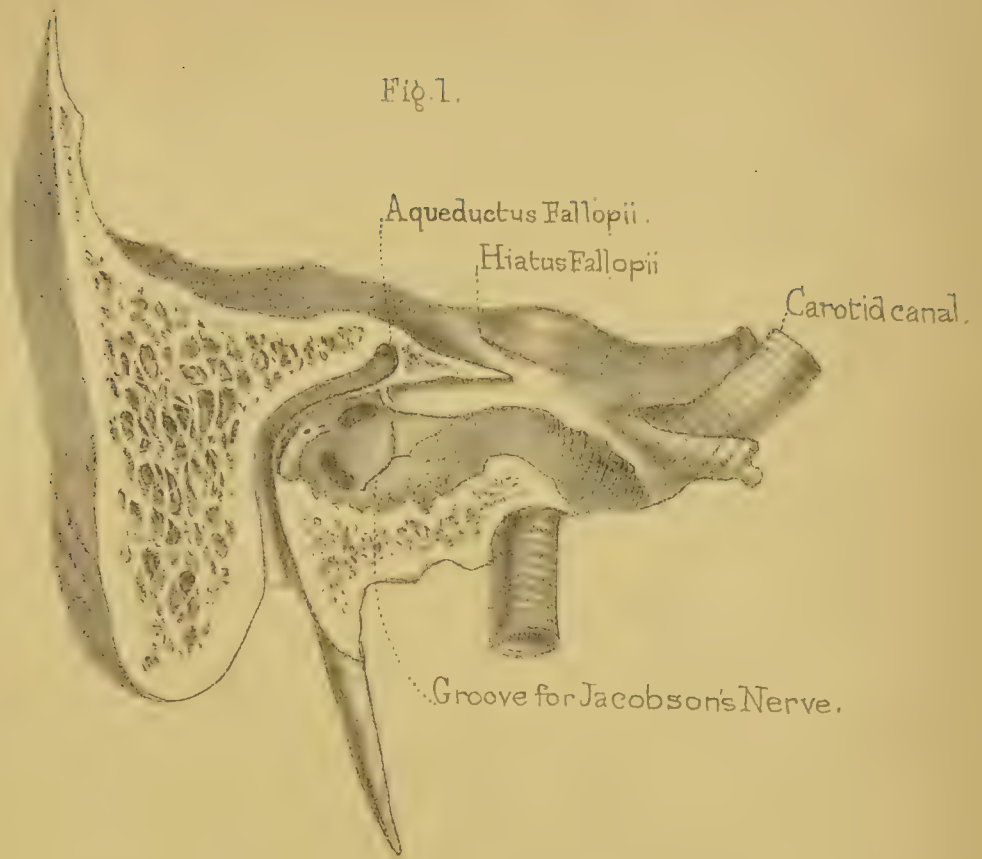


Fig. 2

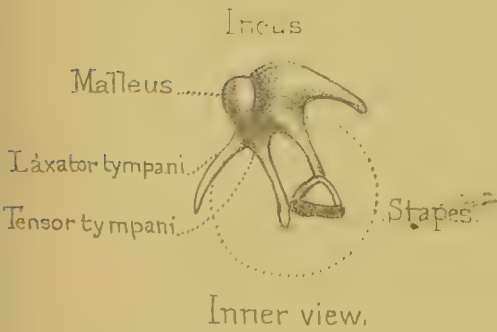


Fig. 3.

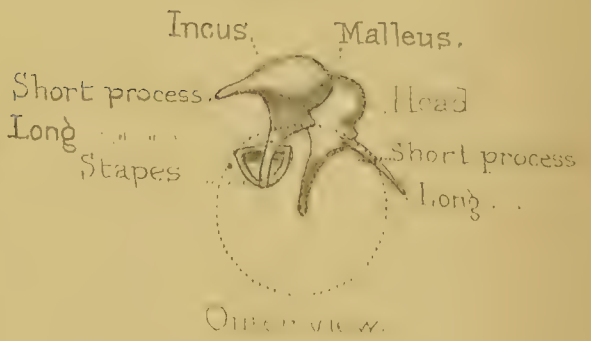


Fig. 4

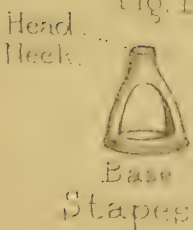
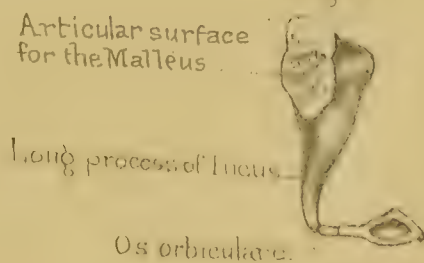


Fig. 5



COCHLEA.

The cochlea, so named from its resemblance to a snail's shell, is an exceedingly curious structure. It is placed so that the base of the shell corresponds to the bottom of the meatus auditorius internus, while the apex points forwards and outwards towards the Eustachian tube. It is formed by the spiral convolutions of two gradually tapering tubes, or rather by one tube separated into two compartments by a longitudinal septum (*lamina spiralis*), composed partly of thin bone, but chiefly of membrane. In the diagram the course of the septum is indicated by a dotted outline. This septum is the most important part of the cochlea, because the auditory nerve expands upon it. It runs all through the tube, except at the apex, where it suddenly terminates in a curved hook, and leaves an aperture (*helicotrema*), so that the two portions of the tube may communicate. One portion of the tube (*scala vestibuli*) opens into the vestibule; the other portion (*scala tympani*) leads into the tympanum through the 'fenestra rotunda.' This last foramen is open only in the dry bone; in the recent state the fenestra rotunda is closed by the '*membrana tympani secundaria*,' which therefore has the air of the tympanum on the one side and the water of the cochlea on the other. The central pillar of the cochlea round which the tube makes two and a half turns is called the '*modiolus*' or '*axis*.'

SEMICIRCULAR
CANALS.

The semicircular canals are three in number, and are called, from their position, '*superior*,' '*posterior*,' and '*external*.' They are placed, we know not why, in planes at right angles to each other like the faces of a cube. Each canal forms the greater part of a circle, and opens at each end into the vestibule. There are only five openings, since two of the canals have an opening in common. Each canal has a dilatation at one end termed the '*ampulla*,' and the reason of this is to make room for a corresponding dilatation of the membranous canal within it, upon which the auditory nerve expands. The '*ampulla*,' therefore, is the most important part of each canal.

PURPOSE OF
THESE ELABORATE
EXCAVATIONS.

Next comes the question, what is the purpose of all these curious and elaborate excavations in the petrous bone? The answer is, to form receptacles for water in which may float the delicate membrane destined

to receive the terminal filaments of the auditory nerve. This membrane is the very essence of the organ of hearing. It is to the ear what the retina is to the eye. In the vestibule and semi-circular canals it forms a continuous, but closed sac, which copies pretty accurately the shape of these cavities, without being in contact with their bony walls. It is bathed within and without by a thin albuminous fluid. That part of the fluid within the membrane is called the 'endolymph'; that without, the 'perilymph,' or 'liquor Cotunnii.' Within the cochlea the membrane is arranged in a different manner. It forms here the greater part of the 'lamina spiralis,' and encloses a third scale or spiral passage, the 'canalis membranacea,' or 'canalis cochleæ,' absent in the macerated labyrinth. Inside this membranous canal is a series of cellular bodies arranged in a very complicated manner, and known as the 'organ of Corti.' The membranous canal is filled with endolymph; the cavities of the scala vestibuli and scala tympani are occupied by perilymph.

The auditory nerve enters the ear through the meatus auditorius internus. At the bottom of this passage are a multitude of small foramina, which transmit the minute subdivisions of the nerve to their respective destinations. Some are distributed upon the sac in the vestibule; some upon the dilatations (ampullæ) of the membranous semicircular canals; others run down the axis of the cochlea, and are distributed to the structures within the canalis membranacea.

PROBABLE
FUNCTION OF
THESE SEVERAL
PARTS.

Now for the explanation, usually received, of the function of these several parts. The waves of sound, collected by the cartilage of the ear, pass down the external auditory passage, strike upon the membrana tympani, and cause it to vibrate. These vibrations are carried by the little bones across the tympanum to the membrane which closes the 'fenestra ovalis,' or opening into the vestibule. This membrane, thus thrown into vibration, communicates motion to the water in the labyrinth; the filaments of the auditory nerve receive the impression and transmit the sensation of sound to the brain. The vibrations of the membrana tympani excite corresponding vibrations in the air within the

cavity of the tympanum, which again communicates them to the membrane closing the fenestra rotunda, and through this they reach the cochlea. Here we have a ready explanation of the use of the fenestra rotunda and the membrane closing it: that is, we have, interposed between air and water, a tense membrane, which is the very best medium for transmitting, with increased intensity, vibrations from one to the other.

After the preceding sketch of the anatomy of the ear, we proceed now to a more minute description of its component parts. It is taken for granted that the learner is already familiar with the anatomy of the temporal bone described at page 68.

MEATUS AUDITORIUS EXTERNUS. This passage leads to the membrana tympani. Its outer third is formed by a tubular continuation of the cartilage of the ear; its inner two thirds by the osseous canal in the temporal bone. The cartilaginous part is united by fibrous membrane to the rough margin of the processus auditorius. The cartilage, however, does not itself form a complete tube; there is a slight deficiency at the upper part, completed by fibrous membrane. There are also one or two vertical fissures in the cartilage. The object of these breaks in the cartilage is to give greater freedom of motion; but they are interesting practically, as explaining how collections of matter in the neighbourhood of the ear sometimes make their way into the meatus auditorius.

LENGTH. The length of the meatus, measured from the middle of its external orifice to the middle of the membrana tympani, is about one inch and two or three lines. The anterior wall is about one-fourth of an inch longer than the posterior, in consequence of the oblique direction of the membrana tympani.

DIRECTION. The direction of the meatus is inwards and forwards. It describes a slight curve with the concavity downwards. Besides this general curve, the cartilaginous

part is slightly curved with the concavity forwards, and the ossous part with the concavity backwards. Altogether, the meatus has such a curious shape that it cannot be well understood without looking at a cast of it. Of many which I have before me, no two are precisely similar in shape. Every surgeon knows how difficult it is to see the whole of the membrane of the tympanum at one view: one can seldom see more than a part of it, however much the ear be dilated and pulled so as to straighten the outer curve. The narrowest part of the meatus is about the middle. Beyond this point we ought not to introduce the speculum.

MEATUS IN THE
INFANT.

The preceding description of the external auditory meatus refers to its condition in the adult. In infancy, the meatus is extremely short on account of the non-development of the bony portion, which at this period is a mere ring (see 'Temporal Bone'). The membrana tympani, too, is almost on the plane of the base of the skull: this is a conspicuous feature in the cranium of a new-born child, where the membrane absolutely lies on the floor of the meatus. It is most important that a surgeon should bear these facts in mind when examining the ears of very young children.

Insects sometimes find their way down the meatus and cause intense pain. I will adduce an instance related by Wilde,* if only to show how to dislodge them: 'I remember being out shooting with a friend, who, suddenly exclaiming "Oh, an earwig!" and throwing aside his gun, fell on the ground, making the most piteous groans, and rolling about in agony. Suspecting that some insect had got into his ear, I procured some water from a ditch, and poured it into the meatus. While watching the result, a little animal, well known among anglers as the hawthorn fly, crept out, and my friend was instantly relieved.'

MEMBRANA
TYMPANI.

The membrana tympani is a thin, semi-transparent, fibrous membrane, of a greyish colour, placed very obliquely at the bottom of the meatus auditorius externus. Its direction is downwards, forwards, and inwards.

* 'April Surgery,' p. 178.

The reason of this obliquity would seem to be, to increase the extent of surface; so that every wave of sound, reflected down the meatus, must fall upon it. Its circumference, which is nearly circular, is fixed into a groove in the bone, so fine that it might have been traced with the point of a needle. (Plate LVIII. fig. 2.) This groove, however, does not form a complete circle: it is deficient at the upper part, where the membrana tympani is, more obviously than elsewhere, continuous with the skin lining the meatus.

The membrana tympani is not flat, like the parchment of a drum, but slightly conical, with the apex towards the tympanum. This shape seems given to it by the handle of the malleus, which draws the membrane a little inwards. The handle of the bone can be seen in the living subject, like a thin white streak, which is not quite vertical, but inclines slightly backwards.

I have many times found a hole in the membrane, even in cases where there has been during life no defect of hearing. This sufficiently explains why some persons can blow the smoke of tobacco through the ear as well as through the nose.

STRUCTURE OF THE MEMBRANA TYMPANI. Thin as it is, the membrana tympani is very strong. It has three strata: an outer stratum of cuticle; a middle, fibrous, on which its strength chiefly depends; and an internal, mucous. (Plate LX. fig. 3.) The middle stratum is composed of fibres radiating and circular, but no longer considered muscular. It is this coat which is fixed into the bony groove, and contains in its very substance the handle of the malleus. The dermal stratum is composed of an extremely thin layer of the true skin, continuous with that lining the meatus auditorius externus. The mucous lining is continuous with the lining of the tympanum. The membrane is well supplied with blood by arteries derived from the stylo-mastoid and the tympanic branch of the internal maxillary.

TYMPANUM, OR MIDDLE EAR. We need not repeat what has been said already about the tympanum, but pass on to

examine what is to be seen on its several aspects, namely: its external aspect, its internal, its anterior and posterior, its superior and its inferior.

EXTERNAL ASPECT. On the outer aspect of the tympanum there is the bottom of the meatus auditorius, closed by the membrana tympani.

INTERNAL ASPECT. On the inner aspect of the tympanum (Plate LVIII. fig. 2) we see—1. The fenestra ovalis leading to the vestibule: this is open in the dry bone, but closed in the recent state by the base of the stapes which is held to the margins of the fenestra by ligamentous fibres. The fenestra ovalis looks outwards towards the membrana tympani. 2. The fenestra rotunda: this, in the recent state, is also closed by membrane (membrana tympani secundaria); in the dry bone it leads to the tympanic scale of the cochlea, and also into the vestibule: but the fenestra does not communicate with the vestibule in the perfect state. The fenestra rotunda looks almost directly backwards. 4. The promontory: this is nothing more than the bulging of the first turn of the cochlea; its surface is marked by grooves for the ramifications of Jacobson's nerve.

ANTERIOR ASPECT. On the anterior aspect of the tympanum, we have—1. The bony canal for the 'tensor tympani' (in the drawing, this canal is cut open). Just before its termination in front of the fenestra ovalis, the canal makes a sudden curve outwards, in order to form a little pulley for the tendon of the muscle within. In most bones this part of the canal is broken, and has the appearance of a little spoon; for this reason, it is called the 'processus cochleariformis.' 2. The Eustachian tube. 3. The orifice of the Glaserian fissure which transmits the 'laxator tympani' and the chorda tympani nerve. In about five specimens out of six, the chorda tympani runs through a little canal of its own, close to, and a little above the Glaserian fissure; but this 'canal of Huguier,' as it has been termed, is of no practical moment, and hardly deserves a new name.

Fig. 1.

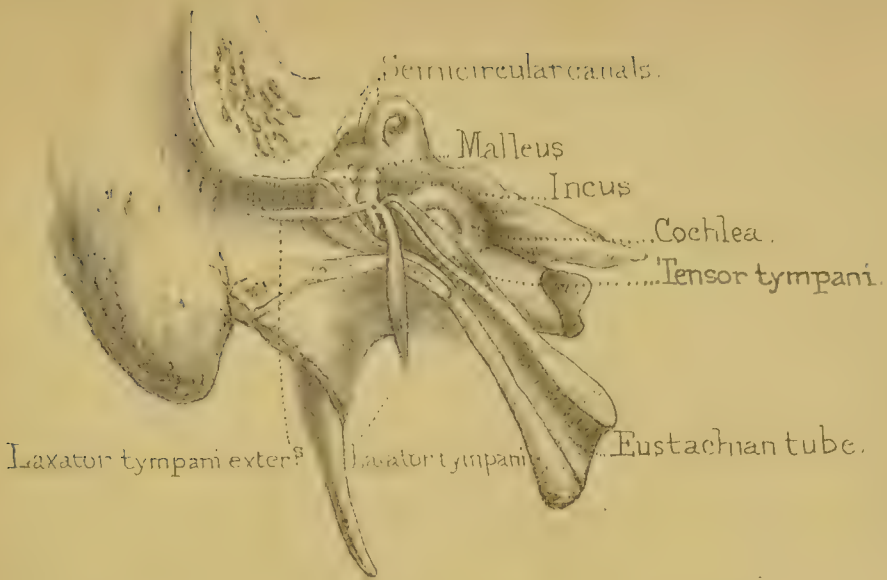


Fig. 2.

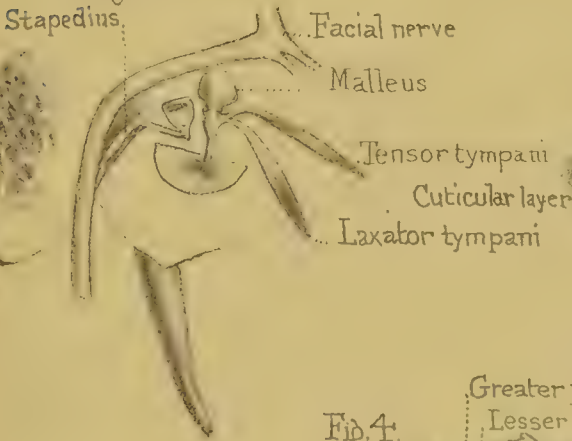
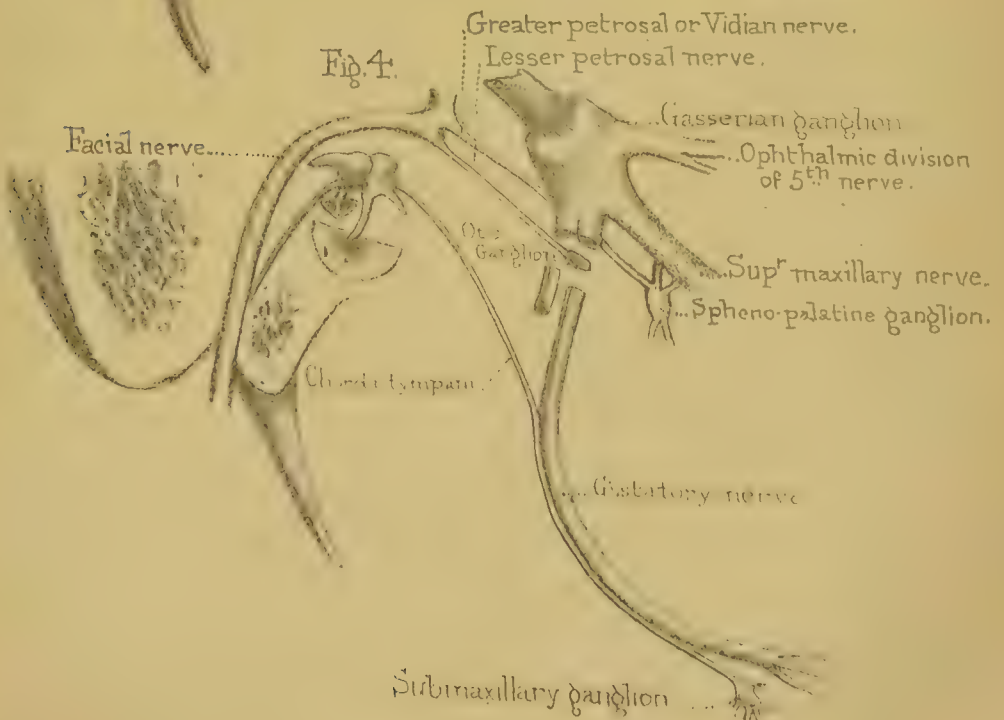


Fig. 3.



Fig. 4.



POSTERIOR
ASPECT.

On the posterior aspect of the tympanum, we have—1. The opening into the mastoid cells. 2. The pyramid—a small projection containing a minute canal, about the size of a bristle, for the lodgment of the ‘stapedius muscle.’* The pyramid is always supported by a minute bony column, which extends like a flying buttress from its apex to the promontory. 3. The foramen chordæ, or ‘iter chordæ posterius.’ This minute foramen is a little below the level of the pyramid, and close to the groove for the attachment of the membrana tympani. Introduce a bristle into it, and you find that it leads into the ‘aqueductus Fallopii.’ It transmits the chorda tympani nerve. This nerve is a branch of the facial (which, remember, is contained in the ‘aqueductus Fallopii’: see Plate LX. fig. 4). It comes up through the foramen chordæ, runs, not across the tympanum, but across the membrana tympani, outside the mucous membrane, between the handle of the malleus and the long process of the incus; it leaves the membrane through the Glaserian fissure (or through a distinct canal of its own), and, joining the gustatory, eventually goes to the submaxillary ganglion.

SUPERIOR
ASPECT.

On the superior aspect of the tympanum is a thin plate of bone which separates the cavity of the tympanum from that of the cranium. This is an important relation. Ulceration commencing in the cavity sometimes destroys this thin plate of bone, and occasions death by involving the dura mater and the brain.

INFERIOR
ASPECT.

The inferior aspect, or floor of the tympanum, is formed by the jugular fossa, which lodges the jugular vein. A little in front of this fossa is the canal for the carotid artery, which is separated from the tympanum only by a thin scale of bone. The vicinity of these great vessels explains the sudden and profuse hemorrhage which sometimes, though rarely, occurs from the ear when diseased. Professor Porter speaks of blood gushing from the ear with a rapidity such as he

* At the base of the pyramid (but within it) are two minute canals which transmit, the one an artery, the other a nerve, to the stapedius.

never witnessed in a surgical operation.* Ulceration had extended into the carotid artery.

In another case of sudden and profuse bleeding from the ear, Mr. Syme tied the carotid artery.† The patient died. Dissection discovered that the blood came from the lateral sinus, near the jugular fossa, the thin bony septum between that fossa and the tympanum having been destroyed by ulceration. Looking at the proximity of these large vessels, we cannot wonder that bleeding from the ear, after injury to the head, makes one suspect the existence of a fracture through the tympanum.

In the floor of the tympanum there are a number of minute holes, among which we especially note *one* as the upper opening of the canal for Jacobson's nerve. The lower opening of the canal is at the base of the skull, on the little crest of bone which separates the jugular fossa from the carotid canal. The nerve in question is a branch of the glosso-pharyngeal. It enters the tympanum, and ramifies upon the promontory, forming what is called the 'tympanic plexus.' It supplies the mucous membrane of the tympanum. Its principal branches are generally indicated by grooves made for their passage on the promontory. In a preparation where there appeared to be neither groove nor nerve, I subsequently found the nerve lodged in a complete bony canal within the promontory.

AQUEDUCTUS FALLOPII. We must not leave the tympanum without noticing the 'aqueductus Fallopii,' or canal for the facial nerve, which supplies all the muscles of expression. (Plate LIX. fig. 1.) Commencing at the bottom of the meatus auditorius internus, it runs for a short distance outwards, then turns horizontally backwards along the inner wall of the tympanum, just above the fenestra ovalis, and, lastly, descending behind the tympanum, emerges at the stylo-mastoid foramen. Its course suggests how liable the nerve is to be injured in fracture through the temporal bone, or in disease of the ear. While in this canal

* Graves's 'Clinical Medicine,' vol. i.

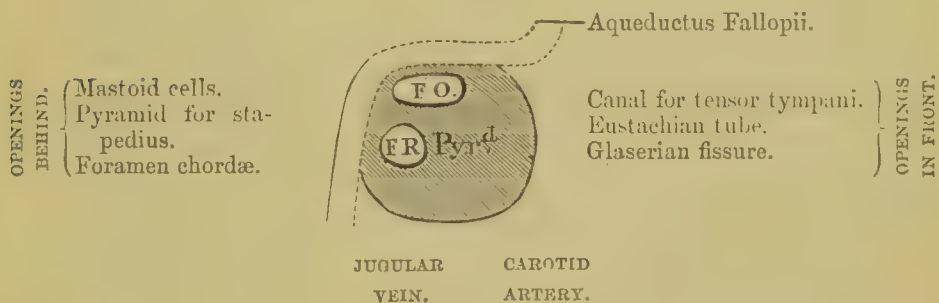
† 'Edinburgh Monthly Journal,' No. III. A case is recorded in the 'Edinb. Med. and Surg. Journal,' No. CXV. p. 319, in which Mr. Syme tied the carotid for hæmorrhage from the ear. The patient recovered.

the nerve sends off three important branches, all to ganglia. These I have endeavoured to show in Plate LX. fig. 4. The first branch, the greater petrosal, or Vidian, runs down the hiatus Fallopii to the spheno-palatine ganglion; the second, or lesser petrosal, goes to the otic ganglion; the third, or chorda tympani, runs with the gustatory nerve to the submaxillary ganglion. Two less important nerves are also given off from the facial in the aqueductus Fallopii, namely, the external petrosal which communicates with the sympathetic on the middle meningeal artery, and the nerve to the stapedius muscle.

To assist the memory, I have arranged the objects seen on the inner wall of the tympanum in the following tabular form:—

FIG. 83.

BRAIN.



LITTLE BONES IN THE TYMPANUM.

The three little bones in the tympanum are drawn larger than natural, but in their proper relative position, Plate LIX. figs. 2, 3, 4, and 5. In fig. 3, you are supposed to be looking at them from the meatus auditorius; in fig. 2, from the inside of the tympanum. The dotted line in each figure is intended to represent the outline of the membrana tympani.

MALLEUS.

The malleus or hammer presents a head, neck, and handle (manubrium). The 'head' is the large round part above the membrana tympani. It articulates posteriorly with the incus by means of a concavo-convex joint, crusted with cartilage and provided with synovial membrane. The 'neck' is the narrow portion between the head and the handle. From the front of the neck springs the 'long process' or 'processus gracilis' which runs down the Glaserian fissure and gives insertion

to the 'laxator tympani.' In infants this 'processus gracilis' may be removed entire, together with the rest of the malleus; but, in the adult, it is adherent to the temporal bone and cannot be extracted entire. The handle or 'manubrium' descends nearly perpendicularly from the neck. Near the root of the handle is a little projection called the 'short process,' which presses against the upper part of the membrana tympani. The handle itself terminates in a slightly flattened, outwardly curved extremity, a little below the centre of the membrane. On the inner side of the handle, and below the processus gracilis, is inserted the 'tensor tympani.'

Hold the malleus with the articular surface backwards and the manubrium downwards; the 'processus brevis' will point to the side to which the bone belongs.

INCUS. The incus, or anvil, lies behind the malleus. It has a body, a short, and a long process. The body is convex, placed above and behind the membrana tympani, and has a concavo-convex surface which articulates with the head of the malleus. The 'short process' extends horizontally backwards into the mastoid cells, and is fixed there by a ligament. The 'long process' descends nearly vertically, parallel to the handle of the malleus, and, like it, is a little convex outwardly. Towards the extremity it suddenly turns up and supports, on a narrow pedicle, the orbicular process formerly termed 'os orbiculare' (fig. 5.).

Hold the incus with its short process backwards and its articular surface upwards; the long process will then be found to turn *away* from the side to which the bone belongs.

OS ORBICULARE. The little 'os orbiculare,' considered by some as a separate bone, is always anchylosed in the adult to the long process of the incus; but it is connected with the stapes by a very distinct joint.

THE STAPES. The stapes, or stirrup, is placed horizontally, with the base in the fenestra ovalis. It has a head, neck, two 'crura' or branches, and a base or foot-plate. The head articulates by a concave surface with the orbicular process

of the incus. The neck gives attachment behind to the 'stapedius.' (Plate LX. fig. 2.) The anterior branch of the stirrup is shorter and less curved than the posterior; both are grooved, probably for lightness' sake,* on their concave sides, and the interval is closed by a membrane. The 'base' is similar in form to the fenestra ovalis, which it nearly fills, and their margins are united by an annular ligament. The lower border of the base is straighter than the upper, and its anterior extremity is the sharpest.

Place the stapes with the straighter border of its base downwards and the sharper end forwards; the head will then point to the side to which the bone belongs.

RIGHT OR LEFT?
 OSSIFICATION. All the bones in the tympanum are ossified and well developed at birth. I have before me the ear-bones of a new-born infant and those of the giant O'Bryan, who was seven feet seven inches high, and there is very little difference between them in size. The plan on which they ossify is remarkable, but incomprehensible to the student until he has mastered the rudiments of embryology.† Of the four bones, the stapes is the most essential to hearing. Disease may destroy the others, and still the patient may hear: but when the stapes falls out, the fluid in the vestibule escapes, and inevitable deafness results.

LITTLE MUSCLES
 MOVING THE BONES
 IN THE TYMPANUM. There are two well-marked muscles with fleshy bodies and distinct tendons attached to the bones in the tympanum, namely, the tensor tympani and the stapedius. (Plate LX. figs. 1, 2.) The 'laxator tympani' is still described as a muscle by many anatomists. The laxator tympani externus, as a muscular structure, is very doubtful.

TENSOR
 TYMPANI. The 'tensor tympani' is a well-marked muscle. It arises from the apex of the petrous bone, and from the cartilage of the Eustachian tube, and is inserted into the handle of the malleus, just below the processus gracilis. The muscle is lodged in the bony canal running above and parallel with the Eustachian tube; and when its tendon reaches the end of the

* Eysell states that the groove in the crus forms half an Haversian canal, lodging a small vessel.—'Beiträge zur Anatomie des Steigbügels,' Archiv für Ohrenheilkunde, vol. v.

† See Quain's 'Anatomy,' 8th edition.

canal, which forms a kind of elbow, it is reflected at a right angle to reach its insertion. From origin to insertion the muscle is enclosed in a strong fibrous sheath. The tendon slides within the sheath, and has a synovial membrane. The ‘laxator tympani’ arises from the spine of the sphenoid bone, runs up the Glaserian fissure, and is inserted into the processus gracilis of the malleus. Like the last muscle, it is surrounded by a sheath. Whilst there is no doubt whatever about the muscularity of the ‘tensor tympani,’ many modern anatomists who have minutely studied the ear, believe the ‘laxator tympani’ to be a ligament.

LAXATOR
TYMPANI.

The ‘stapedius’ arises in the canal of the pyramid. Its little tendon, coming out of the canal at the apex, is reflected outwards, and inserted into the posterior part of the neck of the stapes. Anatomists are not agreed about the precise use of the stapedius. One of its actions would appear to be to tilt the stapes backwards, and thus diminish the pressure upon the fluid in the vestibule.

STAPEDIUS.

So much for the tympanum and its contents. Let us now pass on to the internal ear or labyrinth, comprising the vestibule, semicircular canals, and cochlea. And first of the vestibule, which we enter through the ‘fenestra ovalis.’

The vestibule is of an oval form, measuring about $\frac{1}{5}$ th of an inch in diameter, except from without inwards, in which direction it is not quite so wide. Posteriorly it receives the five openings of the semicircular canals and the opening of the ‘aqueductus vestibuli’; anteriorly, and at its lower part, is the opening into the vestibular scale of the cochlea; on its external wall is the ‘fenestra ovalis.’ In all, then, there are eight openings into the vestibule. The internal wall of the vestibule corresponds with a part of the bottom of the ‘meatus auditorius internus.’ Looking attentively at this inner wall, as shown in Plate LXI. fig. 3, we observe two slight depressions separated by a bony ridge. The upper of the two is called the ‘fovea hemi-elliptica,’ it lodges the utricle; the lower, or ‘fovea hemispherica,’ lodges the saccule. The ridge dividing these ‘foveæ’ is known as the ‘crista vestibuli.’ The utricle and the saccule, as we shall

VESTIBULE.

Fig. 1.

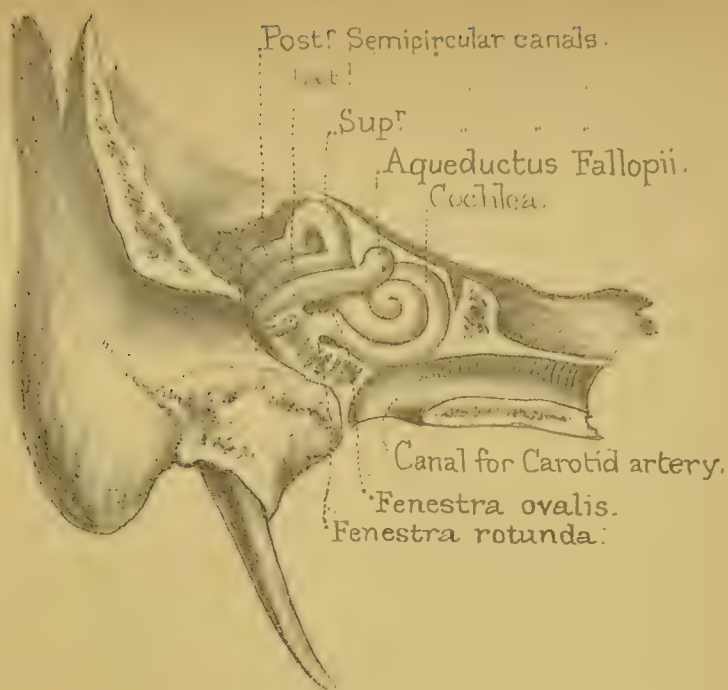
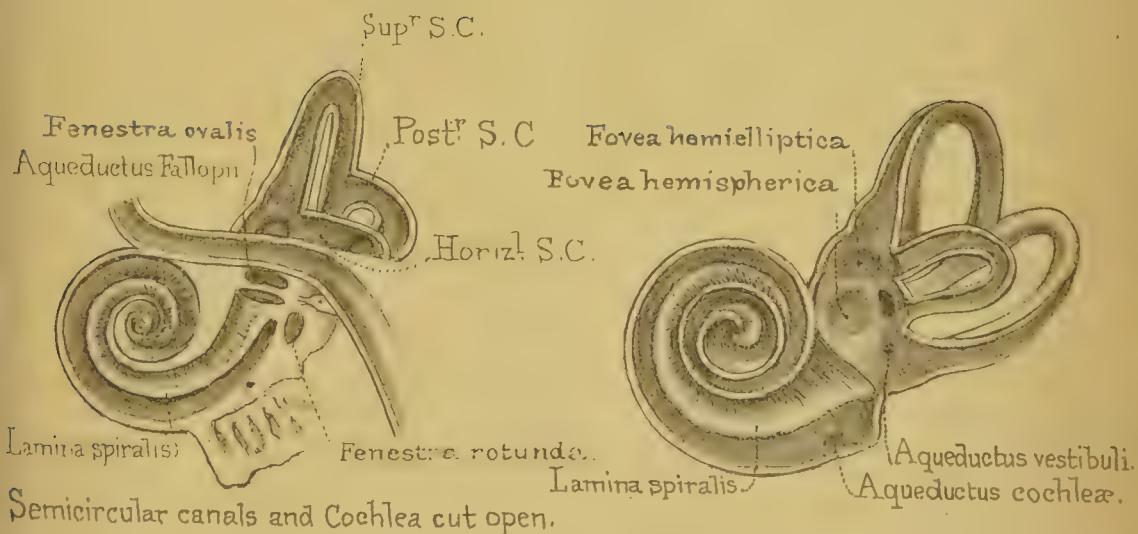


Fig. 2.

Fig. 3.



Vestibule opened to shew its inner wall.

Fig. 4.

Foramen in centre of modiolus.



Hamulus of Lamina spiralis.

Apex of Cochlea.

presently explain, are distinct parts of the membranous labyrinth. The foveæ as well as the crista vestibuli, are riddled with minute foramina, only visible with a lens, through which the filaments of the auditory nerve enter the vestibule. We have attempted to represent the vestibule and its eight openings in the annexed diagram, fig. 84.

FIG. 84.

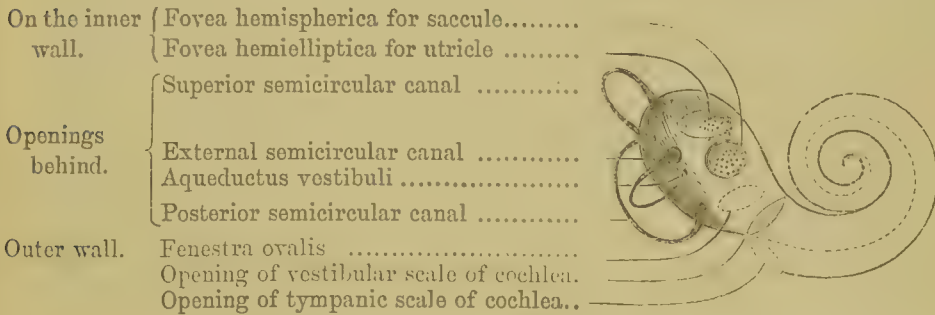


DIAGRAM OF THE RIGHT VESTIBULE, AND THE OPENINGS INTO IT.

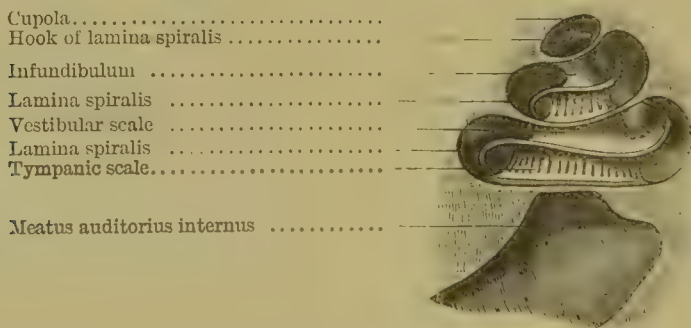
SEMICIRCULAR CANALS. The three semicircular canals are called, according to their position, the ‘superior,’ the ‘posterior,’ (both vertical), and the ‘external’ (horizontal). The *superior* canal crosses the petrous bone at right angles, and stands out in relief on its anterior surface. Its ‘ampulla’ is at the outer orifice. The *posterior* canal is the longest of the three. It runs parallel with the posterior surface of the petrous bone, and makes a little relief just above the aqueductus vestibuli. Its ‘ampulla’ is at the lower orifice; its upper orifice joins the narrow end of the superior canal. The *external* canal is the smallest of the three; it lies horizontally in the petrous bone behind the superior and external to the posterior canal; its convexity is directed backwards. Its ampulla is at its outer orifice.

COCHLEA. The cochlea is placed so that its base is at the bottom of the meatus auditorius internus, ready to receive certain filaments from the auditory nerve. Its apex is directed forwards and outwards close to the canal for the tensor tympani. It makes two turns and a half, which run from left to right in the right ear, and from right to left in the left, round the central axis termed the ‘modiolus.’ Its first

turn, bulging into the tympanum, makes the 'promontory' there. The outer wall of the coil is composed of a lamella of very hard bone, like the semicircular canals: the inner wall is also formed of compact bone, but the interior of the 'modiolus' is spongy. The last half-turn presents peculiarities, and the best way to examine them is to remove the 'cupola' or rounded apex of the cochlea, as we have done in Plate LXI. fig. 4. In this drawing you observe that the last turn forms a kind of half-funnel (infundibulum). Into the apex of this funnel, which is continuous with the modiolus, there opens a canal which runs through the centre of the modiolus. Round the free border of the half-funnel projects the hook-like termination (hamulus) of the lamina spiralis. All this is seen only in the dry bone. In the recent state there would be simply the aperture of communication (helicotrema), between the two scales of the cochlea.

The tympanic scale runs on that side of the lamina spiralis which looks towards the base of the cochlea. Near the beginning of that scale is the minute termination of the aqueductus cochleæ. (Pl. LXI. fig. 3.)

FIG. 85.

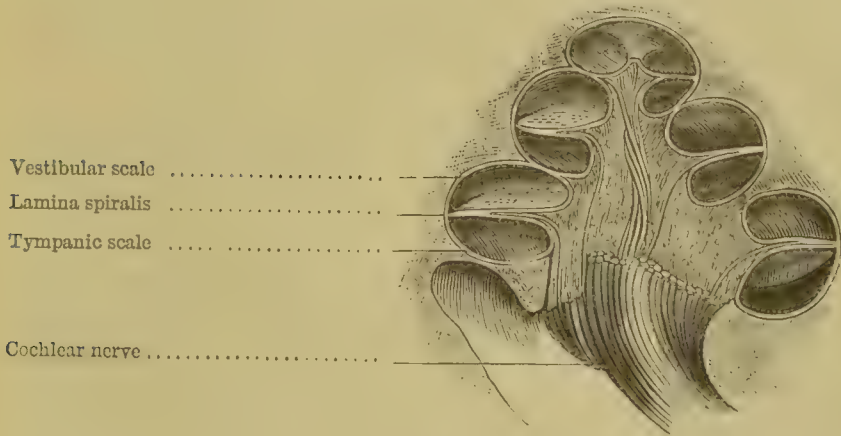


BONY LAMINA SPIRALIS.

The bony lamina spiralis, the only portion of the most essential part of the cochlea which can be seen in the dry bone, is well shown in fig. 85. It commences at the lower part of the vestibule immediately above the fenestra rotunda. (Plate LXI. fig. 3.) From this, which is its broadest part, it gradually diminishes in breadth as it winds round the axis into the apex of the cochlea, never reaching more

than half across the tube, and it finally terminates as a little hook (hamulus) in the funnel of the last coil. On the concave side of this hook is situated (in the recent state) the helicotrema or aperture of communication between the two scales. Now if you examine the lamina spiralis with a lens, you find that both its surfaces are furrowed by canals which give passage to the nerves before they reach the membranous part of the septum. You also observe that it is composed of two very delicate and brittle plates which separate from each other at the axis. In the tympanic scale you may notice the orifices of the canals just alluded to; they are separated by little columns of bone which give rise to a fluted appearance, shown in fig. 85. These columns themselves are made up of bundles of little tubes, enclosing the filaments of the auditory nerve.

FIG. 86.



MODIOLUS. The axis (modiolus) of the cochlea is conical. The base is at the bottom of the meatus internus; the apex does not extend beyond the second turn of the cochlea, and joins the funnel formed by the last coil. The axis is composed of brittle and porous bone, and its interior is traversed by numerous canals which transmit the cochlear nerves to the lamina spiralis. One canal (*canalis centralis modioli*), larger than the rest, runs through the centre of the axis, and opens on its summit, that is, at the apex of the funnel. It transmits a nerve to the last turn of the lamina spiralis.

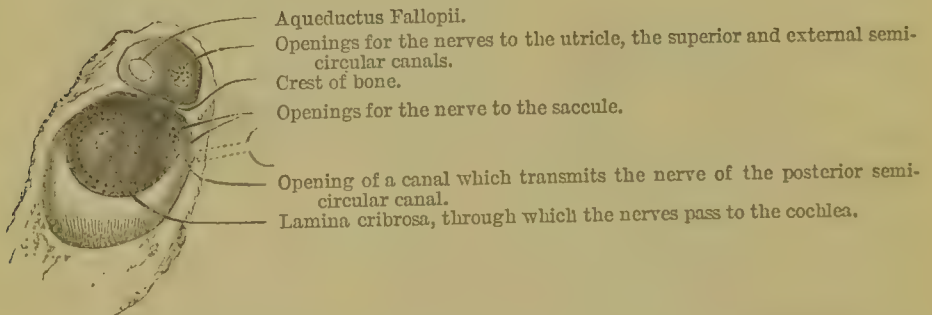
FORAMINA AT
THE BOTTOM OF
THE MEATUS AUDI-
TORIUS INTERNUS.

The meatus auditorius internus is situated on the posterior surface of the petrous bone. Its direction is nearly horizontally outwards; its length, about three-eighths of an inch. Its diameter varies a little in different bones, but is always larger than that of the nerves which it transmits.

The interval between the nerves and their bony canal is occupied by the cerebro-spinal fluid. In fractures through the base of the skull, involving the meatus, this fluid sometimes oozes out through the external ear. Whenever you observe this after an injury to the head, be on your guard. In thirteen cases of injury to the head admitted into St. Bartholomew's Hospital, blood or watery fluid flowed from the ear. Of these thirteen, six died, and in all six the corresponding petrous bone was found fractured. In the seven cases that recovered, five had bleeding from the ear, and two only had a discharge of fluid. So that although a watery discharge be a very unfavourable symptom, it is not necessarily a fatal one.

By cutting away the greater part of the meatus, as we have done in fig. 87, you find that the bottom of it is divided by a

FIG. 87.

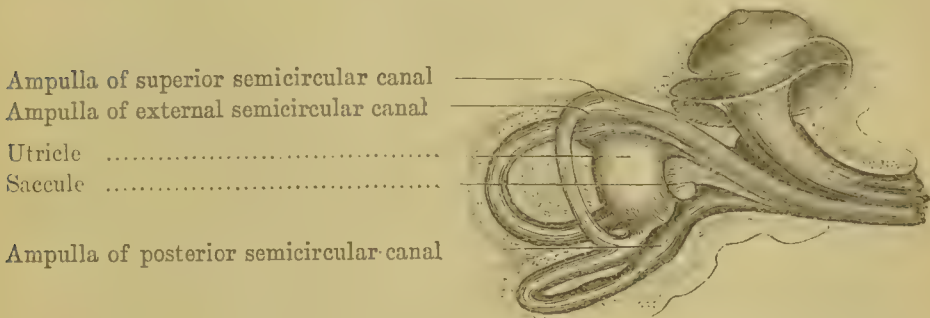


FORAMINA AT THE BOTTOM OF THE RIGHT MEATUS AUDITORIUS INTERNUS.

crest of bone into two compartments of unequal size, an upper and a lower. In the upper and smaller one, there are two openings, of which the anterior is the aqueductus Fallopii (transmitting the facial nerve); the posterior, when examined with a lens, presents a number of minute foramina which transmit the divisions of the vestibular nerves which supply the utricle, the superior and the external semicircular canals.

In the lower and larger depression, we observe the base of the axis of the cochlea, termed 'lamina cribrosa,' because it has a double row of foramina arranged spirally, as shown in the cut. Now take any one of these foramina, which appear scarcely larger than the point of a pin, magnify it with a lens, and you find that it becomes a fossa pierced by holes varying in number from three to seven. So fine are the canals which transmit the filaments of the cochlear nerve! In the centre of the lamina is the orifice of the central canal of the axis, which is the largest of all. Behind the lamina are two (sometimes three) openings leading to minute perforations which transmit the nerve to the 'sacculæ.' Lastly,

FIG. 88.



MEMBRANOUS LABYRINTH AND NERVES OF THE LEFT EAR.

on the posterior wall of the meatus is the orifice of a very constant canal (represented by the dotted outline) which gives passage to the vestibular nerve of the posterior semicircular canal.

MEMBRANOUS LABYRINTH. The membranous labyrinth comprises the two little bladders, termed the 'utricle' and the 'sacculæ,' in the vestibule, and the membranous semicircular canals together with part of the cochlea. It floats in the perilymph, and contains the endolymph. It is partly represented in fig. 88.

UTRICLE. The utricle occupies the upper half of the vestibule. It is very difficult to make a good display of it. The best way to examine it, is to remove very carefully the roof of the vestibule and that of the superior semicircular canal, and then to put the preparation into water. All the membranous semicircular canals open into it. It floats free in the perilymph

except at its fossa, the 'fovea hemielliptica,' where it is retained against the sieve-like plate of bone through which the utricular nerves enter. The utricle sends a slender canal down the aqueductus vestibuli, which ends in a blind extremity outside that aqueduct at the back of the petrous part of the temporal bone. This canal is joined, close to its origin, by another from the sacculle. Thus the utricle and sacculle do communicate, though indirectly.

SACCULE.

The sacculle is smaller than the utricle and situated below it, close to its appropriate fossa, the 'fovea hemispherica.' It is attached to this fossa by the saccular nerve in the same way as the utricle is attached by nerve filaments to the fovea hemielliptica. The sacculle is connected with the membranous canal of the cochlea by a small duct, the 'canalis uniens.' The utricle communicates with the sacculle in the indirect manner just described. Hence the different parts of the membranous labyrinth communicate throughout, like the same parts in the bony labyrinth.

OTOLITHS.

On the inner wall of the utricle and sacculle, at the spot where the nerves spread out upon them, is a small mass of crystals of carbonate of lime. The two masses are the 'otoconia' or 'otoliths,' and are homologues of the large white 'ear-stones' seen in the cod and whiting, and found in most of the osseous fishes.*

MEMBRANOUS SEMICIRCULAR CANALS.

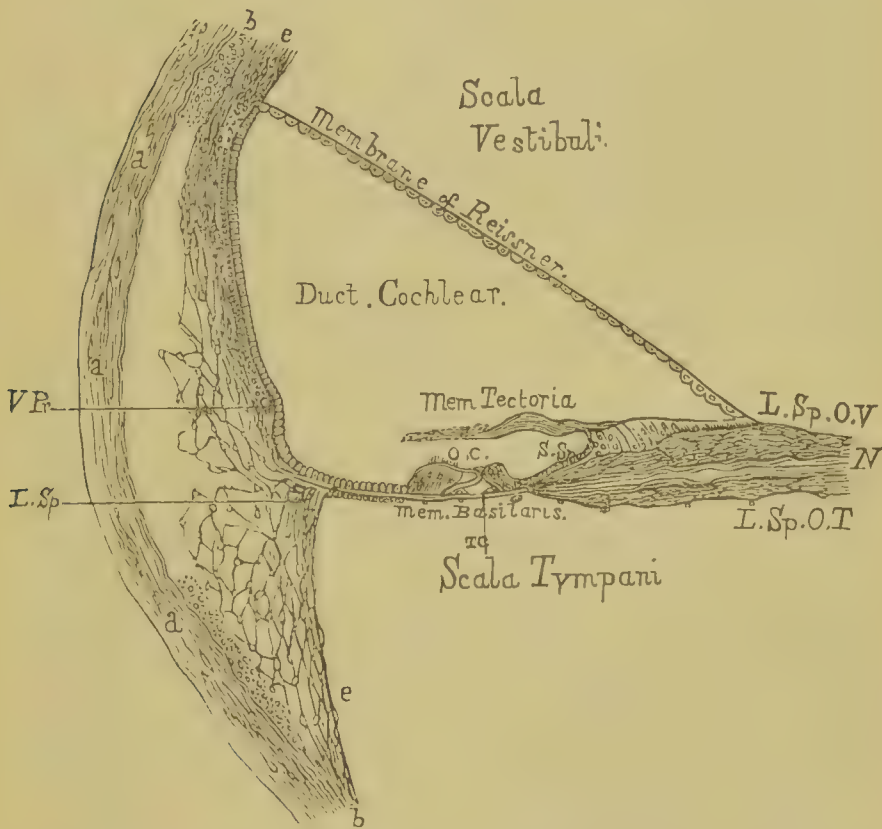
The membranous semicircular canals, except at their ampullæ, only fill about one third the space of the bony canals; the remainder is occupied by the perilymph. The nerve destined to each membranous ampulla spreads out only on that surface of the ampulla which is towards the convexity of the rest of the canal. The nerve does not advance beyond the ampulla, but ramifies on a crescent-shaped septum (septum transversum) which projects into the interior.

* For details concerning the minute structure of the vestibule and the connection of the otoliths with certain hair-like bodies belonging to the nerve filaments, see Dr. Urban Pritchard's paper on 'The Termination of the Nerves in the Vestibule and Semicircular Canals of Mammals.'—'Quarterly Journal of Microscopic Science,' October 1876.

MEMBRANOUS
COCHLEA.

The membranous cochlea forms a third scale, the 'scala media' or 'canalis' or 'ductus cochlearis' (fig. 89), separating the scala vestibuli from the scala tympani. Its floor is attached to the margin of the bony lamina spiralis (L.Sp.O.V., L.Sp.O.T.), and reaches across to the outer wall of the cochlea, to which it is attached by a process of periosteum, the 'ligamentum

FIG. 89.



VERTICAL SECTION OF THE FIRST TURN OF THE COCHLEA, SHOWING THE MEMBRANOUS COCHLEA AND THE POSITION OF THE ORGAN OF CORTI. AFTER WALDEYER AND QUAIN.

spirale' (L.Sp.). This floor is named 'membrana basilaris,' or 'membranous lamina spiralis.' The roof is a very delicate membranous lamina, the 'membrane of Reissner,' it is turned towards the vestibular scale. Hence the 'scala media' is bounded by the 'membrana basilaris,' 'the membrane of Reissner'; and the segment of the outer wall of the cochlea included between the outer attachments of these two membranes. This 'canalis cochlearis' communicates

at one end with the saccule by the 'canalis uniens,' so that the endolymph is continuous in both those cavities; at the other end, towards the apex of the cochlea, it terminates in a blind extremity fixed to the wall of the cupola, partly bounding the helicotrema.

ORGAN OF
CORTI.

In this 'canalis cochlearis,' resting on the 'membrana basilaris,' are two rows of cells (fig. 89 O.C.), an outer and an inner, leaning towards each other, so that there is a tunnel (T.C.) formed between them. They are covered, but only partially, by a membrane (membrana tectoria) attached to the edge of the bony lamina spiralis. Their singular characters and very complicated appendages are subjects too minute to be described here. A full description of this 'organ of Corti,' as the cells are termed collectively, will be found in the eighth edition of 'Quain's Anatomy.'

PROBABLE USE
OF THE ORGAN OF
CORTI.

This organ is arranged on the principle of the cords or notes of a musical instrument, so that different sets of certain fine appendages to its cells may vibrate according as different kinds of vibrations are transmitted from without to the labyrinth. As they communicate with nerves, these differences can thus make an impression on the brain. Hence, by means of the organ of Corti, we can distinguish musical notes and the refinements of tone in delicate sounds, the remaining portions of the labyrinth being sufficient for ordinary hearing.

INDEX.

ABS		CAR	
	PAGE		PAGE
A BSORBENTS of bone	13	Bone, classification of	5
Acetabulum.....	172, 180	development of, in cartilage ...	29
Acromion	142	" in membrane ..	27
Adaptation of man to erect attitude	244	divisible into layers.....	8
Alveolar processes, lower jaw	109	elasticity of	5
upper jaw.....	93	formation of	27
Ampullæ of semicircular canals	261, 273	increase of, in length	34
Anatomical neck of humerus	146	" thickness	34
Ankle joint, bones of	203	lacunæ of	14, 19
Antrum of Highmore	92	lamellæ of.....	14
walls of... ..	90	microscopic appearances of.....	13
Aqueductus cochleæ.....	74	nerves of	12
Fallopîi	73	nomenclature of	6
vestibuli	74	shaft of, why hollow	6
Arch of foot	208	strength of	5
pelvic	188	structure of	2
pubic.....	176, 191	uses of	1
of a vertebra	39	tissue.....	16
Artery of marrow	11	Brim of pelvis	190
Articular bone.....	22		
cartilage ..	22		
processes of vertebræ	39, 48		
Arytenoid cartilages	251	C ALCANEUM	212
Astragalus	210	Callus	37
Atlas	42	Canaliculi of bone.....	14, 20
Auditory meatus, external	71	Canalis cochlearis.....	278
" internal	73	tarsi	212
process	71	Canals in bone:	
Auricular surface of sacrum	184	accessory palatine	104
Axis	44	anterior dental	91
		anterior palatine	96
		carotid	76
		Haversian	14, 16
		of Huguier	70
		infra-orbital	91
		malar.....	98
		posterior dental	91
		posterior palatine.....	103
		pterygo-palatine	81
		vertebral	52
		Vidian, or pterygoid.....	84
		Cancellous tissue of bone.....	8
		Canine fossa	91
		Carpal arch	160
		Carpus, bones of	159
B ACK, plan of muscles of... ..	238		
Base of skull, from below	122		
Base of skull, from within	119		
Basilar process.....	55		
Bicipital groove	146		
Body of a vertebra.....	38, 48		
Bone, absorbents of.....	13		
air-cells in.....	7		
articular	21		
blood supply of.....	10		
canaliculi of	14		
chemical composition of	2		

CAR		FOS	
	PAGE		PAGE
cartilage, elastic	23	Eminentia innominata.....	57
fibro-	23	Endosteum	12
hyaline	23	Ensiform cartilage	229
ossifying	29	Epiglottis	251
simple	22	Epiphysis, meaning of.....	25
yellow	23	law regulating its union to shaft	25
cells, ethmoidal	87	exception to law	207
frontal	62	Ethmoid bone	86
mastoid	70	Ethmoidal process	106
maxillary	92	Eustachian tube	73
sphenoidal.....	80		
Centres of ossification	24		
Clavicle.....	138	FACE, bones of.....	90
Claviculi of Gagliardi	20	Facial angle.....	137
Clinoid process, anterior.....	82	Femur	191
" posterior	79	Fenestra ovalis.....	266
Coccyx	186	rotunda.....	266
Cochlea.....	261, 273	Fibula	204
membranous.....	279	Fingers, bones of.....	168
Cochleariform process	73	Fissure, glenoid or Glaserian	70
Condylod foramen, anterior	57	sphenoidal.....	82
" posterior.....	58	spheno-maxillary.....	129
" fossa	58	Floating ribs	231, 234
Coracoid process	143	Fontanelles	27, 61
Cornicula laryngis	251	Foot, arches of.....	208
Cornua sphenoidalia	79	bones of.....	208
Coronal suture	67	a lever of the first order.....	209
Coronoid process, jaw	112	play of the arches of	225
" ulna.....	155	Foramen for Arnold's nerve	76
Corti, organ of.....	280	cæcum	65
Costal cartilages, relation to ribs ...	233	condyloid	57
" " sternum	229	dentale	110
Cranium, anterior fossa	119	ethmoidal	88
middle fossa	119	infra-orbital	91
posterior fossa	120	jugular	124
Crest of occiput	56	for Jacobson's nerve.....	76
ilium, its 'lips'.....	174	lacerum anterius	82
Cricoid cartilage	250	" medium	120, 124
Crista galli	86	" posterius	75, 121, 124
Cuboid bone	216	magnum	55
Cuneiform bone of carpus	163	mastoid	71
bones of tarsus.....	217	mentale.....	108
cartilages of larynx	252	obturatum.....	178
		olfactory	86
		optic	78, 81
DENTAL formula in man	94	orbital	88
Development of bone, in cartilage	29	ovale (pelvis)	178
Development of bone, in membrane	27	" (sphenoid)	83
Diaphysis, meaning of.....	25	parietal.....	61
Digital fossa.....	195	rotundum	82
Diploë	11, 62	spheno-palatine.....	104, 128
veins of... ..	118	spinosum	83
Ductus cochlearis.....	278	stylo-mastoid	75
		supra-orbital.....	65
		thyroid	178
		vertebral	38
EAR, anatomy of	259	Vesalii	83
Eminence, frontal	62	Fossa, canine	91
ileo-pectineal.....	175	condyloid	58
parietal	60	digastric	71
Eminentia articularis	69		

MYL

	PAGE
Innominate bone	172
Intercarpal joint	160
Intertrochanteric ridges	195
Interstitial lamellæ	20
Intervertebral fibro-cartilage	38, 51
Ischium.....	177
J AW, buttresses of upper	136
joint of	111
Jaw-bone, lower	108
upper.....	90
Jugular foramen	124
fossa	75
L ACHRYMAL bone.....	101
fossa	66
groove	95, 100
process	106
Lacunæ	14, 19
development of.....	29
Lamellæ of bone	20
Lamina spiralis	261, 274
Larynx	248
Linea aspera	195
ileo-pectinea	174
quadrati.....	194, 195
M ADDER, experiments with	34
Magnum, os	164
Malar bone	98
Malleolus externus	206
internus	203
Malleus.....	270
Manubrium of sternum	229
Marrow.....	9
Mastoid foramen	71
portion of temporal	70
process	70
Meatus auditorius externus.....	71
" internus	73
of nose	132
Mechanics of respiration.....	236
Medullary artery.....	11
membrane	12
Membrana tympani.....	264
Membranous cochlea	279
labyrinth	277
semicircular canals	278
Mental foramen	108
Metacarpus	165
Metatarsus	220
Milk-dentition	94
Modiolus	275
Mylo-hyoid groove	110
ridge	109

NAS		SAC	
	PAGE		PAGE
N ASAL bones	100	Perichondrium	23
duct	75	Periosteum	12
fossæ	131	value of	35
spine (anterior)	96	vessels of	12
" (posterior)	103	Petrous, portion of temporal	71
" of frontal bone	67	Phalanges of fingers	168
Nerves of bone	12	of toes	223
Nose, meatus of	132	Phosphate of lime, importance of ...	4
posterior openings of	115	Pisiform bone	163
septum of	133	Premaxillary bone	97
Notch, of acetabulum	180	Process, acromion	142
ethmoidal	66	alveolar (lower jaw)	109
ischiatric, greater	175	" (upper jaw)	93
" lesser	175	angular, external and internal	65
sigmoid	108, 112	auditory	71
supra-orbital	65	basilar	55
O CCIPITAL bone	55	clinoid	79, 82
crest	56	cochleariform	73
Odontoid process	44	coracoid	143
development of	53	coronoid, of jaw	112
Olecranon	156	" of ulna	155
Olfactory fossa	86	ethmoidal	106
groove	86	hamular	83
Optic foramen	81	lachrymal	106
groove	81	malar	97
Orbits	128	mastoid	70
Orbital foramina	88	maxillary	106
Organ of Corti	278	nasal	95
Os calcis	212	odontoid	44
Os hyoides	242	olecranon	156
Os innominatum	172	olivary	78
Os magnum	164	palatine	96
Os orbiculare	270	paroccipital	58
Os planum	88	postglenoid	70
Osseous granules	21	pterygoid	83
Ossification, centres of	24	sphenoidal	105
in cartilage	29	spinous (of ischium)	178
in membrane	27	" (of sphenoid)	82
purpose of centres	26	styloid, fibula	205
Osteoblasts	17, 28	" radius	153
Otoliths	278	" temporal bone	74
P ACCHIONIAN glands	61, 116	unciform	89
Palate, arch of	122	vaginal, of sphenoid	81
Palate, bone	102	" of temporal	75
Palatine canals, accessory	104	Pterygoid processes	83
" anterior	96	Pubes	176
" posterior	103	R ADIUS	151
Parietal bone	60	Rami of pubes	176
foramen	61	Ramus of ischium	177
Patella	199	lower jaw	110
Pelvic arch	188	Ribs	229
Pelvis	187	Ridge, mylo-hyoid	109
axes of	190	superciliary	62
diameters of	190	Rima glottidis	254
obliquity of	189	S ACCULE	278
sexual differences in	191	Sacrum	182

	PAGE
Santorini, cartilages of	251
Scala media	278
tympani	261, 274
vestibuli	261
Scaphoid bone of carpus	162
" of tarsus	215
fossa	83
Scapula	141
Sella turcica	78
Semicircular canals	261, 273
Semilunar bone.....	162
Septum of nose.....	133
Sesamoid bones.....	170, 199, 217, 223
Sigmoid cavity, radius.....	153
cavities ulna	155
notch	108, 112
Sinus, meaning of the term.....	56
Skeleton, general survey of.....	244
Skull, as a whole	113
base of	119
bones of.....	55
buttresses of	135
cap.....	115
general observations on	133
lever of the first order.....	133
Sphenoid bone	77
Spheno-maxillary fissure.....	129
fossa	127
Spheno-palatine foramen	104, 128
Spine, anterior nasal	96
ethmoidal	78
of ilium, anterior and posterior	175
of ischium.....	175
nasal (frontal bone).....	67
posterior nasal	103
of pubes	177
of scapula	142
(vertebral column	37, 48
Spinous process of sphenoid bone ..	82
Spongy bone, inferior	105
Spongy bones, of ethmoid	88
Squamous portion, of temporal bone ..	68
Stapes	270
Sternum.....	229
Styloid process, fibula	205
" radius	153
" temporal bone	74
" ulna	158
Superciliary ridge	62
Superior maxillary bone	90
" buttresses of	136
Sutures of skull	113
Symphysis, lower jaw	108
pubis.....	177
sacro-iliac	174, 184
T ABLES of the skull	62, 134
Tarsus, bones of	210
Tarsus, tunnel of	212

	PAGE
Teeth, lower jaw	109
milk	94
upper jaw	94
Temporal bone	68
fossa	116
Thorax	228
Thyroid cartilage.....	248
foramen.....	178
Tibia	201
Torcular Herophili	59
Trapezium.....	163
Trapezoid bone.....	163
Trochanter major.....	194
minor	195
Tubercle, carotid	42
of clavicle	140
of radius	152
of a rib	232
of tibia ..	201
Tubercles of dorsal and lumbar ver- tebræ.....	47
Tuberosity of humerus, greater and lesser.....	146
of ischium	179
of palate bone	103
of radius	152
of tibia, external and internal	201
Tunnel of tarsus	212
Turbinated bone, ethmoidal	88
,, inferior	105
,, sphenoidal	79
Tympanic bone.....	72
Tympanum.....	259, 265
U LNA.....	155
Unciform bone	164
process	89
Utricle	277
V AGINAL process of sphenoid bone.....	81
of temporal bone	75
Venous canals in the diploë	118
Ventricles of the larynx	253
Vertebræ, cervical	41
dorsal	40
lumbar	40
general description of	38
• Vertebral canal	52
column	37, 48
curves of	50
elasticity of	49
extent of motion in	50
form of	51
strength of	49
Vortebræ, ossification of	53
lumbar	40
Vestibulo	260, 272

VOC		ZYG	
	PAGE		PAGE
Vocal cords	252	Wormian bones.....	114
Vomer	107		
W ALKING, mechanism of the		Z YGOMA	69
foot in	226	Zygomatic fossa	127





